INDEXED

Marine Engineering

JULY, 1905.

THE FALL RIVER LINE STEAMER PROVIDENCE.

Built for service between New York and Fall River in connection with her sister ships *Priscilla, Puritan, Plymouth,* and *Pilgrim,* the *Providence* is the fourth of that name owned by the Old Colony Steamboat Company, and is just about to be placed in service. The first *Providence* was built in 1832, and had a measurement of 400 tons; the second boat of the name was placed on the route between New York and Providence in 1865, and was of 900 tons measurement; the third, which was for many years the most famous steamer of her class in the world, was launched in 1856, and had a length of 373 feet. She was broken up in 1901.

THE NEW SOUND STEAMER PROVIDENCE.

The new ship is not the largest in the Fall River Line, but she is by far the most luxuriously fitted, as is evidenced by the fact that her cost has been more than $1,300,000. She has a length over all of 397 feet, a length on the water-line of 378 feet 6 inches, a breadth of hull of 50 feet, and a total breadth over the guards of 88 feet, while the depth of the hull is 21 feet 10 inches and the draft of water 12 feet. Her registered gross tonnage is 4,365.

The *Providence* is licensed to carry 1,200 passengers, and has sleeping accommodations for that number. She has in addition a considerable freight capacity, it being estimated that she can carry 900 tons on her normal draft. The staterooms are distributed as follows: On grand saloon deck, 161; galley saloon deck, 152; and dome deck, 33; making a total of 346, all beautifully decorated and very attractively furnished. At the extreme aft of the gallery saloon is located a music room; forward of this is the social hall. The dining room is at the after end of the lower saloon and is fitted entirely with small tables seating four persons each. Each table holds an electric candelabra, adding considerably to the effect of the room. A private dining room opening from the forward part of the main dining room is handsomely paneled in teak.

The hull is constructed of mild steel with double bottom for the greater part of the length, the appearance being of the familiar sound type of steamer, with a straight stem and semi-elliptical stern, and sponsoned wing walls from the paddlewheels tapering gradually forward and aft and adding considerably to the strength of the ship, as well as securing a great range of stability. The three tiers of deck houses are erected over the main deck and are

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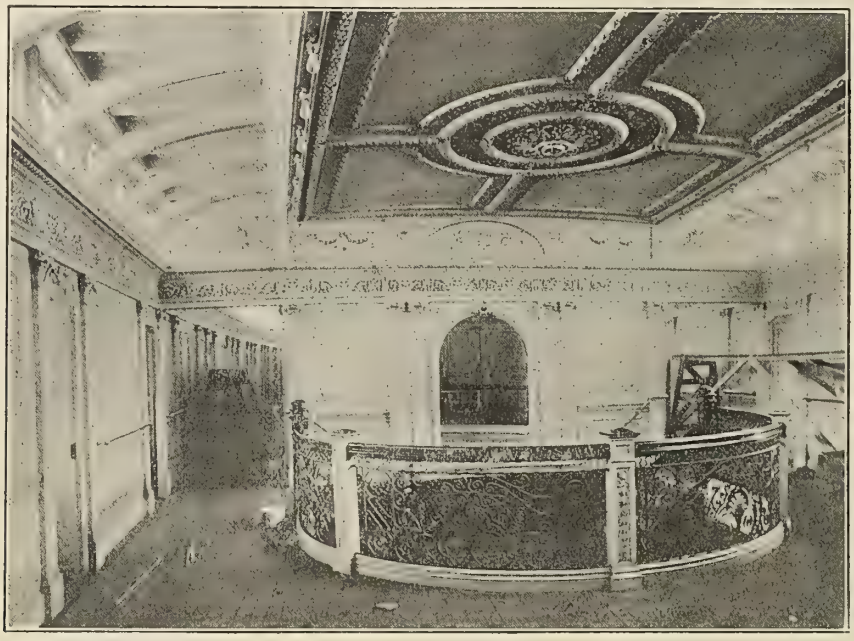
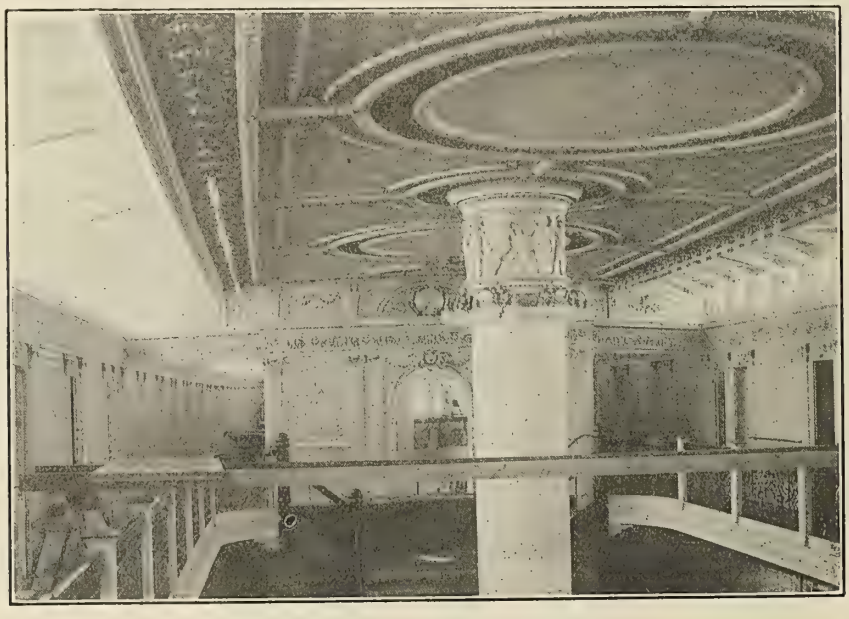
surmounted by two funnels, and the usual flagpoles. The double hull is sub-divided into thirty-eight separate watertight compartments, protecting the vessel against danger from the effects of grounding, and localizing to a very restricted area any damage which might result. In addition to these cellular sub-divisions the hull itself is divided by transverse steel bulkheads into eight watertight compartments, the bulkheads being of sufficient strength to sustain the pressure of water in case any one of the compartments should be filled.



HEAD OF STAIRWAY IN SOCIAL HALL.

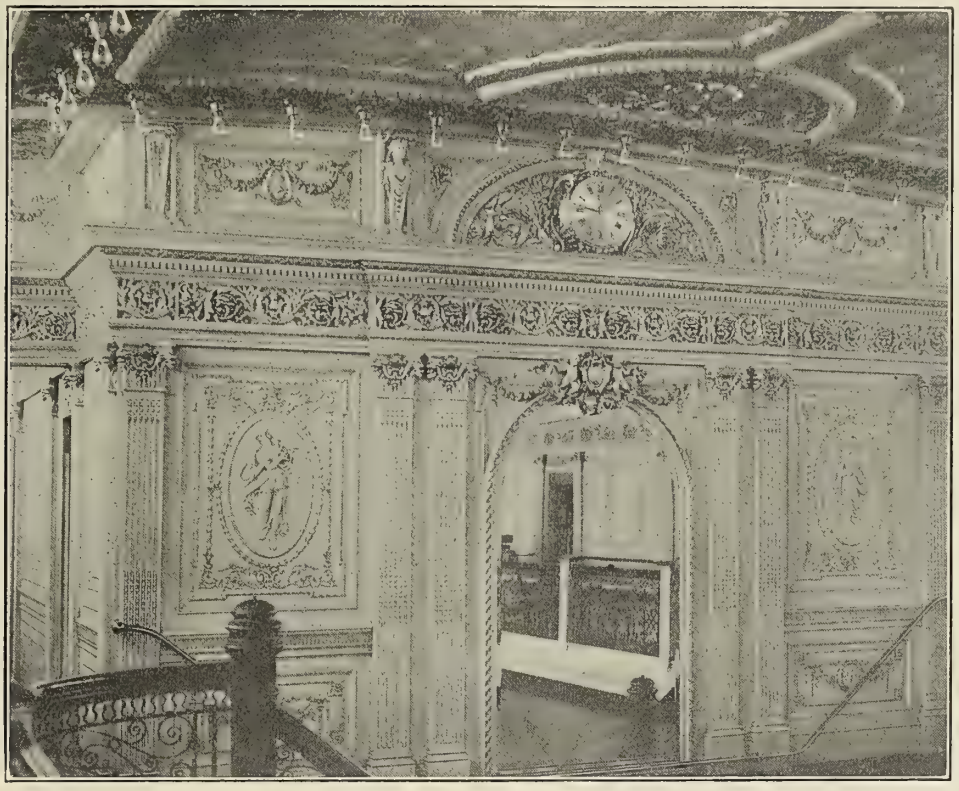
The vessel has a total of seven decks, known respectively as lower, main, saloon, gallery, hurricane, break, and dome. Below the main deck the construction is entirely of steel, but above this point the construction is of wood on a steel frame work. This method of composite construction gives an exceptionally light structure, while retaining the necessary rigidity.

The *Providence* is propelled by iron feathering paddlewheels with an outside diameter of 29 feet 6 inches, each containing twelve buckets 13 feet long and 4 feet wide. These wheels are actuated by double inclined compound engines, the two high-pressure cylinders having a diameter of 44 inches and low-pressure 83 inches, this giving a ratio of piston area of 3.55 to 1; the stroke is 9 feet. The framework of the engine is built up of heavy steel plates secured to the inner bottom and frames of the ship. Stevens valve gear is used with Stephenson link motion and Sickel cut-off. Each engine has a separate condenser with cooling surface of 5,000 square feet, the condenser shells being as usual of cast iron. The circulating water is supplied to each condenser by two 10-inch centrifugal pumps driven by independent vertical engines. The two main air pumps, each 50 inches in diameter by 30-inch stroke, are connected to the low-pressure crossheads by means of links and rocker shafts, each pump having a 16-inch suction opening from the condenser and discharging into the feed-water heater through the hot well and filter tank.



THE CAPITAL AND CEILING DECORATIONS.

The boiler room is situated immediately forward of the engine



THE SIDE WALL DECORATIONS.

room and contains six single-end Scotch boilers arranged back to back in the center of the vessel, with fire rooms outboard extending fore-and-aft and fitted for closed ash-pit forced-draft system. These boilers have a diameter of 14 feet 9 inches and are 12 feet 9 1-2 inches long, having been designed for a working pressure of 152 pounds per square inch. Each contains three corrugated furnaces of an inside diameter of 49 inches together with 308 tubes, 3-inch outside diameter, with a thickness represented by No. 10 B.W.G. The grate surface per boiler is 88.8 square feet, while the heating surface is 2,542 square feet, giving a ratio of heating surface to grate area of 28.6 to 1. The fire rooms are equipped with four ash ejectors, two on each side; the coal bunkers run fore-and-aft and have a total capacity of 200 tons.

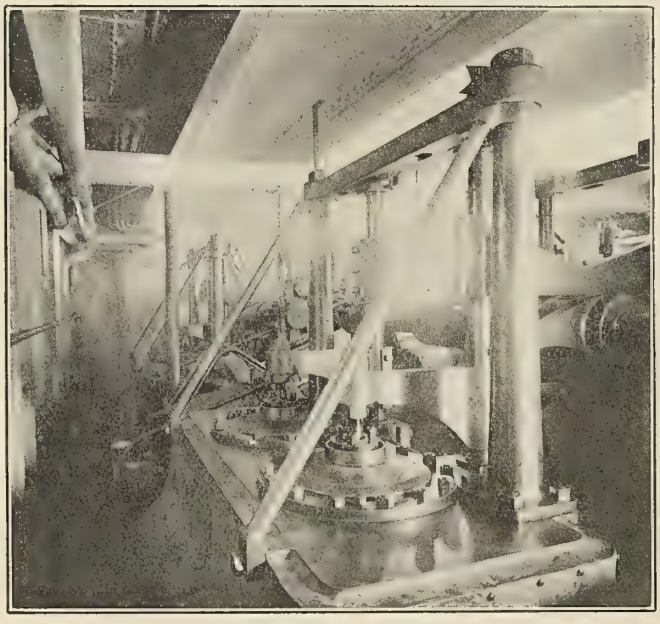
The two funnels are arranged fore-and-aft and are circular in cross section, each having an inside diameter of 7 feet 7 inches and an outside diameter of 8 feet 9 1-2 inches. The height from the grates is 90 feet 3 inches. At the base of each stack is a superheater 11 feet in diameter and 12 feet high. On the main deck just abaft the superheater is a vertical donkey boiler 83 inches in diameter, and built for a working pressure of 162 pounds per square inch; the grate area is 30 square feet and heating surface 862 square feet.

There are two 12-inch by 7-inch by 12-inch Blake horizontal duplex feed pumps, located in the engine room, and connecting with the condenser, the feed-water heater, and the forward and aft feed tanks and discharging into the feed mains. Two other pumps in the engine room are respectively a 12-inch by 9-inch by 7-inch Cameron bilge pump with a 5-inch suction from the secondary drain; and an 8-inch by 5-inch by 12-inch Blake duplex pump for fresh-water service. An additional Blake feed pump is used for the donkey boiler. In addition to the feed pumps both main and auxiliary boilers are equipped with injectors. Two other pumps are fitted in a special room and designed for fire and wrecking service. These are both of the Blake horizontal duplex pattern, one being 18 1-2-inch by 12-inch by 12-inch with a 10-inch suction from main drain, and the other 14-inch by 8 1-2-inch by 12-inch with 12-inch suction from the sea.

The general style of the interior architecture and decoration is French renaissance, strongly influenced by the period of Louis XVI, this being a most graceful character of decorative architecture in lending itself particularly well to the flowing lines of marine work. The color throughout the major portion of the

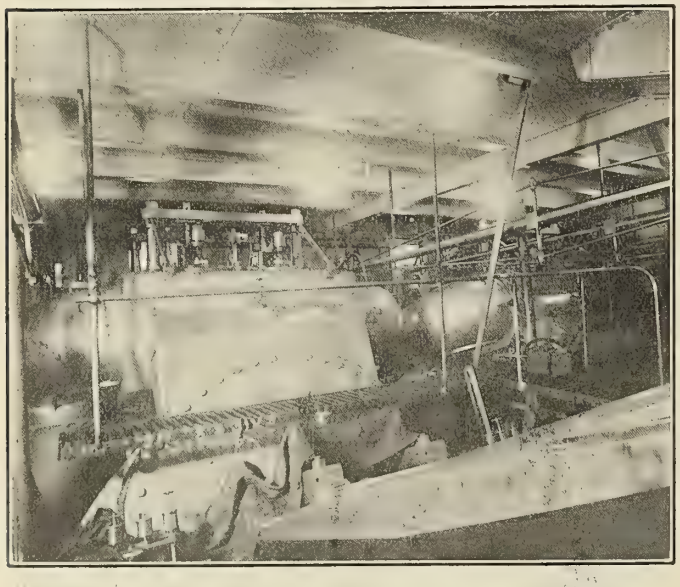
IN THE SOCIAL HALL.

steamer is of rich old ivory accentuated with gold in the prominent relief parts. The iron work of the balustrades is painted a dull black; the electric-light fixtures are of burnished gold finish, and they are so distributed that while the lighting is brilliant the general effect is a soft diffusion of light through all parts of the interior of the vessel. A total of about 1,600 incandescent lamps are used.



THE VALVE MECHANISM.

The electric light generating plant consists of three 50-Kw. General Electric direct-connected marine generating sets, operating at 350 revolutions per minute, and giving a voltage of 110. This plant is located on the main deck in the engine-room inclosure, and distribution is made on the two-wire system. The usual



IN THE ENGINE ROOM.

auxiliary machinery for steering and handling the ship has been provided, including steam- and hand-steering gear, a powerful steam windlass on main deck forward, together with steam capstans for wharfing purposes. The anchor gear consists of two 5,200-pound anchors and 180 fathoms of 1 7-8-inch chain cable with the usual cranes and rolling boards.

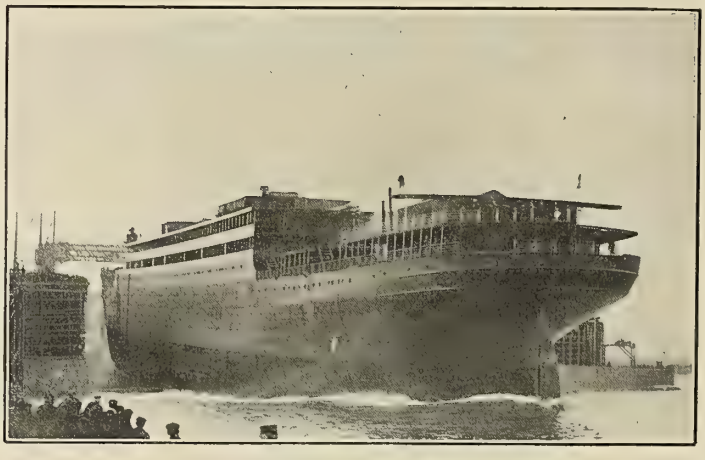
The run of the *Providence* from New York to Providence is 184 miles, which distance is covered in ten hours, although it can be done in nine hours when necessary. The engines, boilers, and all fittings, with boilers full of water, weigh 1,550 tons, and the horsepower of the machinery is about 5,500. The pressure of steam when under ordinary service is only 100 pounds per square inch, although the machinery was designed for a maximum working pressure of 152 pounds. The anticipated coal consumption is 70 tons in the run of 184 miles. This gives the ship one mile on 852 pounds of coal. It also figures out as 2.85 pounds per indicated horsepower per hour.

The life-saving equipment consists of 1,400 life preservers, 12 lifeboats, and 10 life-rafts. The lifeboats are each 26 feet 7 inches in length and 2 feet 6 inches deep; the life-rafts are 20 feet in length with cylinders 22 inches in diameter. The requirements for steel plates, angles, beams, and rivets in the hull call for 1,780 tons, the rivets used being about 700,000 in number. The lumber used in the deck houses and in interior fittings and decks was about 1,500,000 board feet. The steamer is equipped with wireless telegraphy and hence will be in communication with the shore at all points of her passage. She is also equipped with a very complete telephone system, there being one in each stateroom and a total of 375 on the boat.

The *Providence* was designed by the late Mr. George Peirce, and was built by the Fore River Shipbuilding Company, of Quincy, Mass., under the supervision of Messrs. Stevenson Taylor, consulting engineer, and J. Howland Gardner, superintendent of marine construction of the Old Colony Steamboat Company.

Launch of the Hamburg-American Liner Amerika.

On Thursday, April 20, Messrs. Harland & Wolff, Belfast, launched the fine large steel twin-screw passenger steamer *Amerika,* for the Hamburg-American line. The new steamer has a gross tonnage of about 22,800, and when completed will be the largest vessel afloat outside the British mercantile marine. She will be fully fitted up for a very large number of first-, second-, intermediate-, and third-class passengers, the accommodation for the higher class passengers being most elaborate and luxurious, and that for the other classes also exceptionally good. Several new features have been introduced into the vessel, the chief of which are the special restaurant, and a fine recreation room con-



THE AMERIKA TAKING THE WATER.

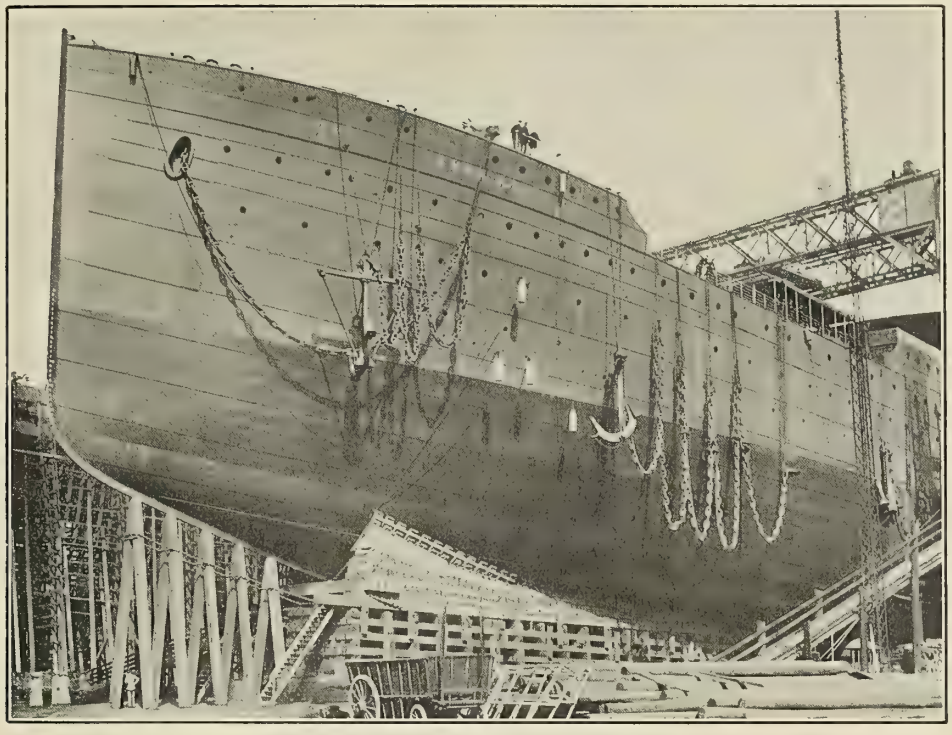
taining a gymnasium and other facilities for athletic exercises, which will also be much appreciated by passengers desirous of such recreation. As usual in the large vessels built by this firm, the machinery is of their quadruple-expansion balanced type, reducing vibration to a minimum, a condition to which much importance is attached. The practical immunity from vibration gained by the

introduction of quadruple expansion and the balanced principle, as scientifically worked out by Harland & Wolff and practically demonstrated in the vessels already built by them, is a significant fact at the present time, as illustrating the perfection to which the reciprocating engine has been brought.

The *Amerika* has a length of 670 feet, a beam of 74 feet, and a depth of 52 feet. The height to the boat deck is 77 feet 6 inches, the displacement 40,000 tons, and the cargo capacity 15,000 tons. The speed for which she was designed is 17.5 knots. She will carry 600 first-class, 300 second-class, 250 third-class passengers, 2,300 immigrants in the steerage, and a crew of 550. The arrangements for the comfort of the first-class passengers are most luxurious, the staterooms containing no upper berths, and some of them being as much as 10 by 17 feet in dimension.

AFTER THE LAUNCHING.

A sister ship to the *Amerika*, to be known as *Kaiserin Auguste Victoria*, is being built at Stettin, and has slightly larger dimensions, but the accommodations are almost identical. The *Kaiserin Auguste Victoria* has a length of 705 feet, the very unusual beam of 77 feet, and a depth of 53 feet 9 inches. Her displacement is 40,000 tons and cargo capacity 16,000 tons, the gross tonnage being about 25,000. These two ships have caused some comment on account of the fact that they are to be equipped with passenger elevators. They will have two funnels and four masts.



THE BOW, SHOWING THE FOREFOOT CUT AWAY.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of June 10, 1905, the following percentage of completion of vessels building for the United States Navy:

				May 1.	June 1.
BATTLESHIPS.					
Virginia	19 knots.	Newport News Co.		85.53	87.38
Nebraska	19 "	Moran Brothers Co.		70.89	72.4
Georgia	19 "	Bath Iron Works		77.78	80.01
New Jersey	19 "	Fore River Shipbuilding Co.		81.1	84.8
Rhode Island	19 "	Fore River Shipbuilding Co.		86.	87.6
Connecticut	18 "	Navy Yard, New York, N. Y.		73.56	77.73
Louisiana	18 "	Newport News Co.		74.83	77.55
Vermont	18 "	Fore River Shipbuilding Co.		47.2	51.1
Kansas	18 "	New York Shipbuilding Co.		51.4	54.
Minnesota	18 "	Newport News Co.		63.18	65.42
Mississippi	17 "	Wm. Cramp and Sons		27.04	29.09
Idaho	17 "	Wm. Cramp and Sons		24.93	27.18
New Hampshire	18 "	New York Shipbuilding Co.		3.2	7.2
ARMORED CRUISERS.					
California	22 knots.	Union Iron Works		75.	76.2
South Dakota	22 "	Union Iron Works		72.9	74.
Tennessee	22 "	William Cramp and Sons		71.8	75.73
Washington	22 "	New York Shipbuilding Co.		74.2	79.3
North Carolina	22 "	Newport News Co		3.25	6.03
Montana	22 "	Newport News Co		3.2	5.32
SEMI-ARMORED CRUISERS.					
St. Louis	22 knots.	Neafie and Levy Co.		63.	65.3
Milwaukee	22 "	Union Iron Works		72.4	73.8
Charleston	22 "	Newport News Co.		93.78	94.88
GUNBOATS.					
Dubuque	12 knots.	Gas Engine and Power Co.		94.28	99.4
Paducah	12 "	Gas Engine and Power Co.		83.9	85.4
TRAINING SHIPS.					
Cumberland	Sails	Navy Yard, Boston		95.	95.
Intrepid	"	Navy Yard, Mare Island		97.5	97.5
TORPEDO BOATS.					
Goldsborough	30 knots.	Wolff and Zwicker		99.	99.
O'Brien	26 "	Lewis Nixon		99.	99.

MOTOR BOATS.

BY DR. WILLIAM F. DURAND.

THE PROBLEM OF THE BOAT.

Ten years ago the motor boat, or boat using some form of internal combustion engine for power, was a comparative curiosity. To-day they are commonplace on almost every harbor, lake, and water course throughout the country, from the Atlantic to the Pacific and the Great Lakes to the Gulf, while in Europe and elsewhere over the civilized world their increase in utility and popularity has been no less marked. As a line of industry collateral with the automobile and gas engine power industries, it has shared in the wonderful growth which these latter have enjoyed, and has furnished opportunity for labor and capital in amounts to suit the capacity of many moderate and small investors in lines of industrial work. A motor-boat plant is not necessarily large or expensive, nor need it absorb any very large capital. It has thus stood as one of the relatively smaller lines of industry into which many might venture with capital which would be entirely without significance in the larger lines of industrial work, and has thus played a beneficent part in aiding the moderate or small industrialist to find outlet for his capital, energy, and skill, while the product has steadily worked its way into the confidence and favor of the public until motor boats of one type or another are found literally by thousands in all parts of the country, and adapted to almost every demand of either commerce or pleasure.

In approaching a discussion of the motor-boat problem it will be well to obtain a clear idea of what may be called in its broadest terms the "Problem of the Boat." This contains the following main items:

(*a*) To design and build a floating structure which, with a certain weight of material, shall with safety be capable of carrying a certain load and admit of propulsion through the water at a certain speed.

(*b*) To design and build a motive power plant which shall serve to liberate, transform, and adapt some store of natural energy into a form available for propulsive purposes.

(*c*) To apply to the purposes of propulsion the power thus transformed, and so to realize the ultimate purpose of the combination of hull, motor, and propeller.

The important points under (*a*) are as follows:

(1) Weight of hull.
(2) Weight of additional load which may be carried.
(3) Resistance to propulsion.
(4) Safety.
(5) Cost of construction and of maintenance.

The fundamental purpose which must be held in view by the designer and builder must be to combine in the highest degree the least weight of structure with maximum capacity for additional load and least resistance to propulsion, all with due regard to safety and to the fundamental factor of all engineering work—the cost of construction and of maintenance.

The important points under (*b*) are as follows:

(1) Weight and space required for motive-power plant.
(2) Efficiency as a means of transforming energy into motive power.
(3) Simplicity, reliability, and general adaptation to the conditions and requirements of the case in hand.
(4) First cost.
(5) Cost of operation and maintenance.

The fundamental purpose here must therefore be to combine in the highest degree the utmost of efficiency as a means of transforming energy into power available for propulsion, the least weight and space required, and the utmost of simplicity, reliability, and adaptation, and all with minimum first cost and costs of operation and maintenance.

The important points under (*c*) are as follows:

(1) Efficiency as a means of utilizing for propulsion the power furnished by the power plant.
(2) Adaptation to the control of the boat, and to any special conditions or requirements which may exist.
(3) Simplicity and reliability.

The fundamental purpose here must therefore be to combine most perfectly the highest efficiency of the propulsive agent as a means of utilizing power for propulsion, with the utmost simplicity, reliability, and adaptation to the ready and sure control of the boat and to any other special conditions or requirements.

A review of these various requirements will show that the efforts toward general advancement must take the following directions:

(1) Decreased weight of hull.
(2) Increased internal space and carrying capacity.
(3) Decreased resistance.
(4) Decreased weight and space required for motive-power plant for a given power, or increased power for a given weight or space.
(5) Increased efficiency of motive-power plant as a means of transforming natural energy into motive power.
(6) Increased efficiency of propulsion.
(7) All with due regard to safety, simplicity, reliability, and the various items of cost.

It will be clear that these various requirements are mutually inconsistent in various degrees, and that no boat can contain all desirable features in the highest degree. In the general design of a boat in any given case it is therefore necessary to give to each of the various requirements and conditions a just relative weight, and then to seek for the best combination of features, having in view the especial purpose for which the boat is intended. Thus in some cases everything must be sacrificed for speed, while in others moderate speed, comfort, and safety are desired; while in others, again, economy of operation with large carrying capacity must be provided; and thus the design as a whole will take shape as the various features are combined in such manner as may best answer the special demands of the case.

It will best answer the purpose of these articles to approach the more detailed consideration of the problem through section (*b*) above, the motive-power plant, its character, design, and installation.

Remembering the fundamental requirement it is clear that the process of power development and application may be worked out in a variety of ways. In the general case the entire process may be divided into three steps or considered under three heads:

(1) The storage of energy.
(2) The liberation or manifestation of energy.
(3) The transformation of energy from the form under which it is first liberated, into mechanical work available for propulsion.

In the familiar steam motive-power plant the coal or oil fuel represents the storage of energy, the boiler provides for its liberation as heat, and the engine and propeller for its transformation and utilization as propulsive work. This is the form of motive-power plant which stands preëminent with reference to the world's work of marine transportation, and it is only in small corners of the broad field, such as that with which we are to be concerned in the present series of articles, that any other form of motive power has gained acceptance.

In the naphtha launch, which represents one of the earliest forms of special motive-power boats, the energy is stored in the naphtha or other form of fuel, while it is transformed by combustion into heat, and then embodied in the naphtha vapor from whence it is transformed by the engine and propeller into the mechanical work of propulsion.

In the alco-vapor launch likewise, the energy is stored in the kerosene, gasoline, or other form of fuel, thence transformed into heat, and embodied in the alcohol vapor, and then by the engine and propeller transformed into the work of propulsion.

In the electric launch, on the other hand, the energy is stored in the cells of a storage battery, whence it is transformed into mechanical work by the motor and into work of propulsion by the propeller.

In the typical modern motor boat using the gasoline combustion engine, the energy is stored in the gasoline, this is transformed into gas and mixed with air in the carbureter, while the energy is liberated as heat in the engine cylinder, and then directly transformed into mechanical work by the engine, and into propulsive work by the propeller.

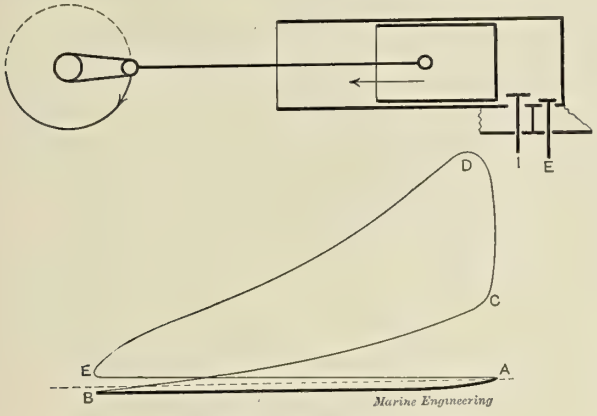


FIG. 1.—FOUR-CYCLE ENGINE, INTAKE STROKE.

In the special type known as the suction-gas engine, using coal as primary fuel, the energy is stored first in the coal and then in the gas formed in the producer. The energy is then liberated as heat in the engine cylinder, and transformed as in other types, ultimately into the work of propulsion.

These brief references to the various forms of solution for the general motive-power problem are introduced at this point simply to show the diversity of special solution which is not only possible but practicable for certain limited requirements, and to impress the relation of each to the other, and the fact that all are but special means of fulfilling certain fundamental conditions common to all problems dealing with the development and utilization of natural energy for power purposes.

THE GAS ENGINE.—PRINCIPLES OF OPERATION.

We must now turn to a more detailed examination of the gas engine and the solution which this furnishes for the general motive-power problem of boat propulsion. In the typical gas engine the main problem is as follows:

Given a hydrocarbon or other form of gas, required its combustion and the transformation into mechanical work of the heat energy thus developed.

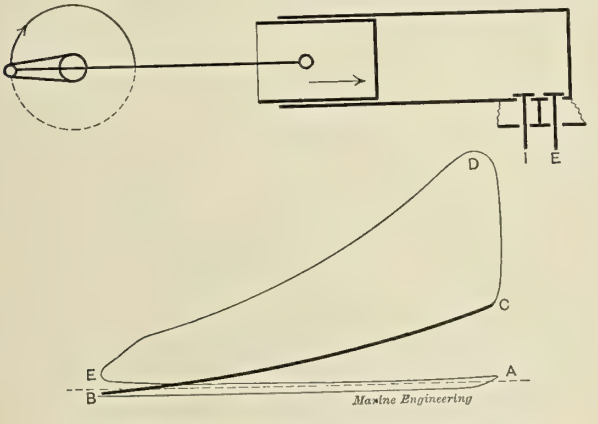


FIG. 2.—FOUR-CYCLE ENGINE, COMPRESSION STROKE.

The first step is combustion or union with oxygen. But the gas itself will not burn, and must therefore first be mixed with a suitable amount of oxygen. This is accomplished most cheaply by using air and accepting the nitrogen present simply as a diluting ingredient of the mixture. Again, it is found that such gases, even when mixed with a suitable amount of air, will not burn readily at ordinary pressures, and it is not until they are compressed to a high degree that the combustion once started will propagate itself with sufficient vigor and rapidity to render the operation practicable and useful as a factor in the cycle of a gas engine.

With this by way of introduction we may proceed with the description of the operation of the typical or four-cycle gas engine. This type of engine receives its name from the fact that the entire cycle of operations is distributed over four strokes of the piston as follows:

(1) Intake of charge of mixed gas and air.
(2) Compression.
(3) Combustion and expansion.
(4) Exhaust.

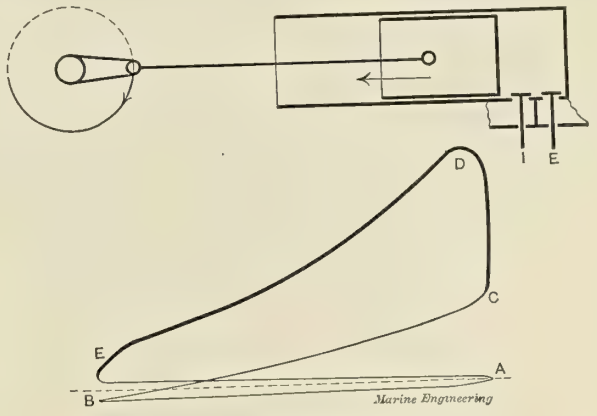


FIG. 3.—FOUR-CYCLE ENGINE, POWER STROKE.

In Fig. 1 the piston is just beginning the intake stroke, the intake valve *I* is open, and the exhaust valve is closed. The piston moves as indicated by the arrow, and at the end of the stroke the cylinder is filled with the charge. This operation is accomplished at a practically constant pressure, slightly below atmospheric pressure, and the line indicating this relation between pressure and volume is shown at *AB*, the intake line of the indicator card *ABCDE*. During the next stroke, shown in Fig. 2, the intake valve is closed and the piston returns on its path thus compressing the gas in accordance with the law of rising pressure shown by the line *BC* of the indicator card. At the close of this stroke the gas is under pressure as denoted by the point *C* and then ready for firing. The ignition being effected by the electric spark, the combustion is rapidly propagated throughout the charge, heat energy is liberated, and the pressure rises as shown by the line *CD*. At the same time the piston begins its third stroke as shown in Fig. 3, urged by the pressure of the expanding gas, the pressure decreasing as the volume increases as shown by the expansion line *DE*. The entire line *CDE* of the diagram corresponds, therefore, to the operations of combustion and expansion, and gives the

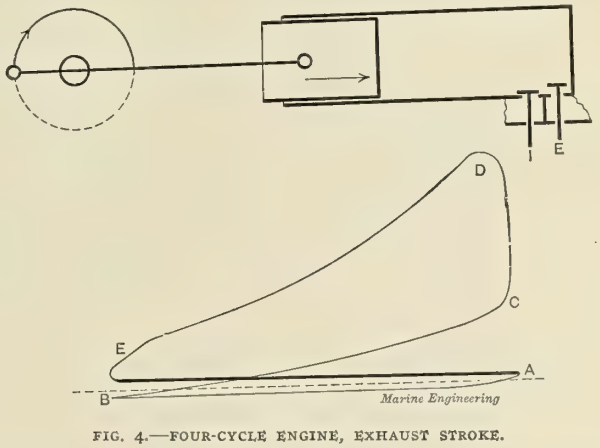


FIG. 4.—FOUR-CYCLE ENGINE, EXHAUST STROKE.

history of the relation between volume and pressure for the third stroke of the cycle. During the next stroke the piston returns to its original position as shown by Fig. 4, and the waste gases are rejected through the open exhaust valve. The corresponding line on the indicator diagram is shown by *EA*, thus completing the diagram and the cycle. The following stroke a new cycle begins and the same operations are repeated.

Referring again to these figures indicating the operation of the engine throughout one complete cycle, it will be clear that the gases act on one side of the piston only, the other side being exposed to the constant pressure of the air. Engines operating in this manner are known as "single acting." It is furthermore clear, since the air always acts by pressure inward, that it will oppose the out stroke and aid the in stroke by equal amounts, and that in consequence the pressure of the air exercises no resultant influence on the net work done by the engine. The net work will therefore be correctly given by considering simply the work done by the gas alone. From this point of view it is seen that during stroke No. 1 the gas comes in with pressure as shown

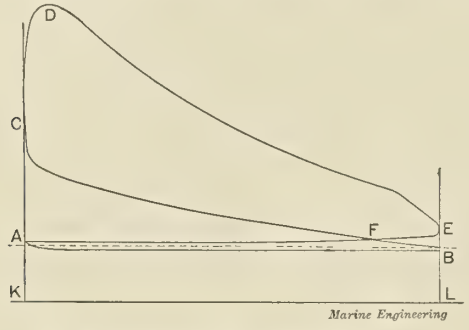


FIG. 5.—INDICATOR CARD, FOUR-CYCLE ENGINE.

by the line *AB*, Fig. 5, slightly below the atmospheric line; but reckoning from the zero of pressure, positive work is done on the piston represented by the area *ABLK*. During the second stroke the gas is compressed and takes work from the engine represented by the area *CBLK*. During the third stroke the gas gives work to the engine represented by the area *KCDEL*, while during the fourth stroke the piston must push the gas out, thereby doing work on it represented by the area *EAKL*. A little thought will show that as the result of these four strokes work is done *by* the gas on Nos. 1 and 3, and *on* the gas on Nos. 2 and 4; and further, that the net work of the cycle will be given by the difference between the two loops of the diagram *CDEF—ABF*.

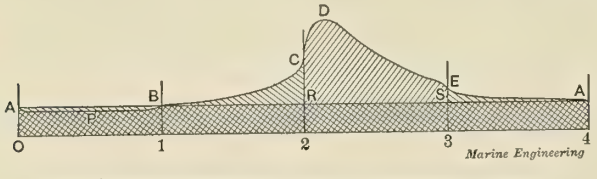


FIG. 6.—DISTRIBUTION OF WORK IN FOUR-CYCLE ENGINE.

While it is evident that the air always pressing in the one direction will not affect the total work of the cycle, it will, nevertheless, affect the net work for each stroke individually, and hence the distribution of net work through the cycle. This is a point of some importance and may be seen more clearly by the aid of Fig. 6.

In this diagram the four lines of Fig. 5 are run out consecutively, the letters being the same in both figures. The four strokes are therefore from *0* to *1*, *1* to *2*, *2* to *3*, and *3* to *4*. The straight line *AA* represents atmospheric pressure and *04* the zero of pressure. Then during the first stroke the work done by the gas and against the air is represented by the area *0APB1*, while the work done on the air is represented by the rectangle *0AB1*. The net work for this stroke is therefore done *on* the air, and is shown by the area *APB*. Similarly during the second stroke the work done on the gas is shown by *1BC2*, and that done by the air is shown by *BR21*. The net work is therefore done *on* the gas, and is shown by the area *BCR*. During the third stroke the work done by the gas is shown by *2CDE3*, and that done on the air by *RS32*. The net work is therefore done *by* the gas and is shown by the area *RCDES*. During the fourth stroke the work done on the gas is shown by *3EA4*, and that done by the air is shown by *3SA4*. The net work is therefore done *on* the gas, and is shown by the area *SEA*. To aid in understanding these various relations, the work done *by* the air or *by* the gas is shown by hatching with lines inclined downward to the left, while work done *on* the air or *on* the gas is shown by hatching with lines inclined downward to the right. The net work for each stroke shows then as a singly hatched area, and the direction of the lines shows whether it is done *by* or *on* the engine. Thus it is clear that for the first, second, and fourth strokes the net work is done *by* the engine either *on* the gas or *on* the air, while for the third stroke the net work is done *on* the engine and *by* the gas. The entire net work for the cycle will therefore be represented by the difference between the area *RCDES* and the sum of the three areas, *APB, BCR, SEA*. A little thought will show that this difference will have the same value as the net result derived from the indicator card of Fig. 5, and as referred to above. It is furthermore evident that the net work of stroke number 3, represented by the area *RCDES*, must be sufficient to provide for the external work (of propulsion, for example) plus the work of internal friction, both for the entire cycle, plus the work represented by the three other smaller areas for the three other strokes of the cycle. It is also clear that the inertia of the moving parts must be depended on to maintain the motion during strokes *1*, *2*, and *4*, for which net work is absorbed rather than given out. This shows in particular the need of a heavy flywheel with a single four-cycle engine giving but one power impulse in four strokes. The application of these principles to multiple cylinder engines will be referred to at a later point. In the meantime it may be noted that the distribution of work through the cycle, as shown by these diagrams, has an important bearing on the operation and adaptation of the engine for various purposes, and the interested reader is urged to obtain a thorough grasp of these various diagrams and of the facts which they represent.

(To be continued.)

THE COURSES IN MARINE ENGINEERING AND NAVAL ARCHITECTURE AT COLUMBIA UNIVERSITY.

BY PROF. AMASA TROWBRIDGE.

In looking over the field of naval architecture and marine engineering to-day, we see that we are in the midst of a period of development that promises many new things before its completion. The steam turbine and the gas engine have been tried and found available, and will both be brought to practical perfection in the next few years. This is just what is to be expected, if we judge from the development that has taken place in this field in the last century. In the course of this development, many of the steps have been first taken in the United States, though for many years we have done a very small percentage of the shipbuilding of the world. It is probably due to the fact that we have done so little of the recent shipbuilding, that we were so long without any schools of naval architecture and marine engineering. This is a lack that can hardly be laid at the door of those who were conducting our scientific and technical schools, as they have shown themselves extremely ready to adopt suggestions in the line of new courses. Rather, it must have been due to the lack of demand for highly trained scientific men in the shipbuilding industry. As our shipbuilders have begun to compete with the shipyards of other countries, notably those of Great Britain and Germany, it has been found necessary to have a corps of highly trained men, familiar with the reasons for doing things, as well as with the methods of doing them. To get these men, many of the shipyards have employed foreigners, or those who were educated in foreign schools. The results have not always been what

were expected and have seldom been what was desired. Very few of these men have been able or willing to put themselves into a proper place in the system of an American shipyard, and the consequence has been an utter lack of co-operation.

Without an adequate system and a fair degree of co-operation, no industry of the magnitude of a shipbuilding plant, and especially one dealing with such a variety of work and processes, can be carried on successfully. Then, too, few industries present the difficulties to be found in shipbuilding. The work is large, but it must be done with great care. The various parts must be assembled in a certain order, and must fit each in its respective place; but they must frequently be made in different parts of the works, and often in different works. In designing the ship, each part has a direct influence on many others, yet the whole design problem is so large for a big ship that many men must work on it at once. This tends, of course, to lead to many delays and much confusion, from changes made by one man necessitating changes in parts designed by another man. To meet these difficulties, it requires men who are in sympathy with the ideas of those who are directing the work, and who are also interested in the development of new methods for doing the work. To us new methods are a necessity. Labor is higher priced here than in Europe, but materials need be no higher. The fact that steel, the material from which most of the ship is built, costs more here at present, is no proof that it *must* cost more. In fact, when our steel manufacturers find no room for their product in the home markets, they can easily undersell foreign steel makers, delivering the material across the water for actually less than it can be manufactured there. Hence we see that if the American shipbuilder can introduce enough labor-saving devices, he should be able to compete with the foreign builders.

It has been the experience of many reformers of manufacturing processes that, to make their reforms successful, they must educate young men to do the work rather than get experienced men, who were accustomed to the old methods, to change their ways. Shipbuilding is no exception to this rule.

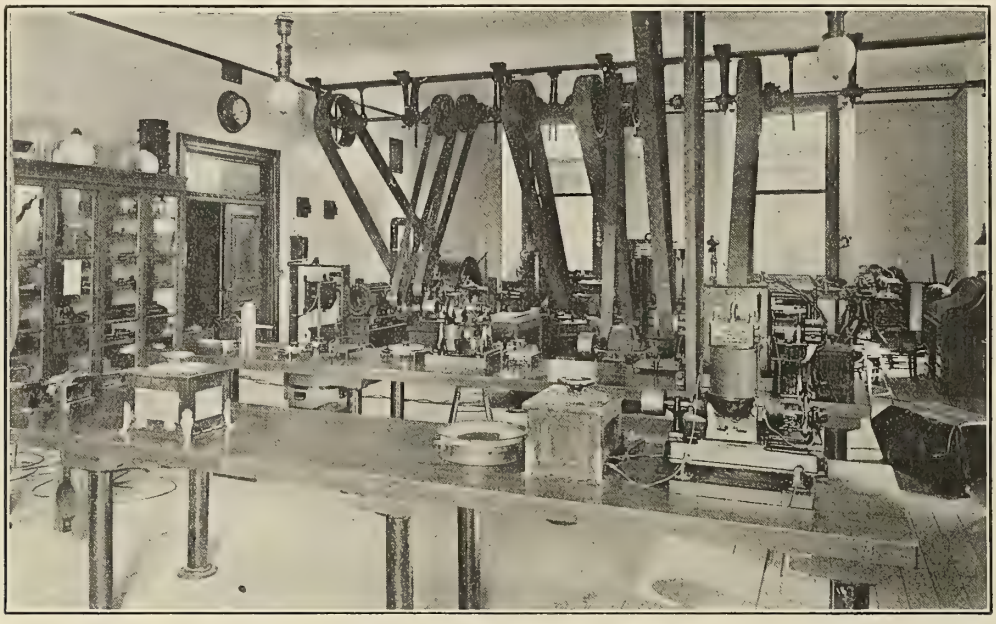
To meet the demand for highly trained men in shipbuilding, some of our American universities have offered marine courses. This was done at Columbia University about five years ago, and the courses have been undergoing development ever since. Located at the very center of American shipping industries, Columbia has unequaled facilities for instruction in naval architecture and marine engineering. The ships of all nations come to her very doors, and she is literally surrounded by yards where the building and repairing of vessels is constantly being carried on. The greatest navy yard in America, that in Brooklyn, is within easy reach, and here many examples of warship construction can be seen, as the vessels of our navy, from the smallest launches to the largest battleships, are built or repaired. Also, in Brooklyn, Staten Island, and on the New Jersey shore are shipyards where naval and merchant vessels are built and repaired. Then, too, only a few minutes' trip northward brings us to the Harlem River, where some of the most advanced types of high-speed vessels, yachts, and torpedo boats are constructed.

GENERAL VIEW OF COLUMBIA UNIVERSITY.

The course in Columbia is a four years' course, covering as broadly as possible the necessary subjects which it is desirable a man should understand to fit him for the profession of naval architect or marine engineer. The first and second years are largely devoted to the fundamental studies, such as mathematics, physics, and chemistry, and the third and fourth years to the more purely technical studies. One of the strong features of the course is the engineering laboratory work, in which the student is required not only to perform experiments, but also to analyze his results, thus enabling him to gain a proper perspective from which to judge probable results from similar conditions in any other case. The laboratory is very completely equipped with the various types of engines, including a reversing engine fitted with Stephenson link motion. A 30-horsepower steam turbine is also installed, and can be readily used for almost any kind of experiment, as it can be placed in any convenient spot, no foundation being required on account of its perfect balance. The effect of multiple expansion of steam can be studied, as there are single,

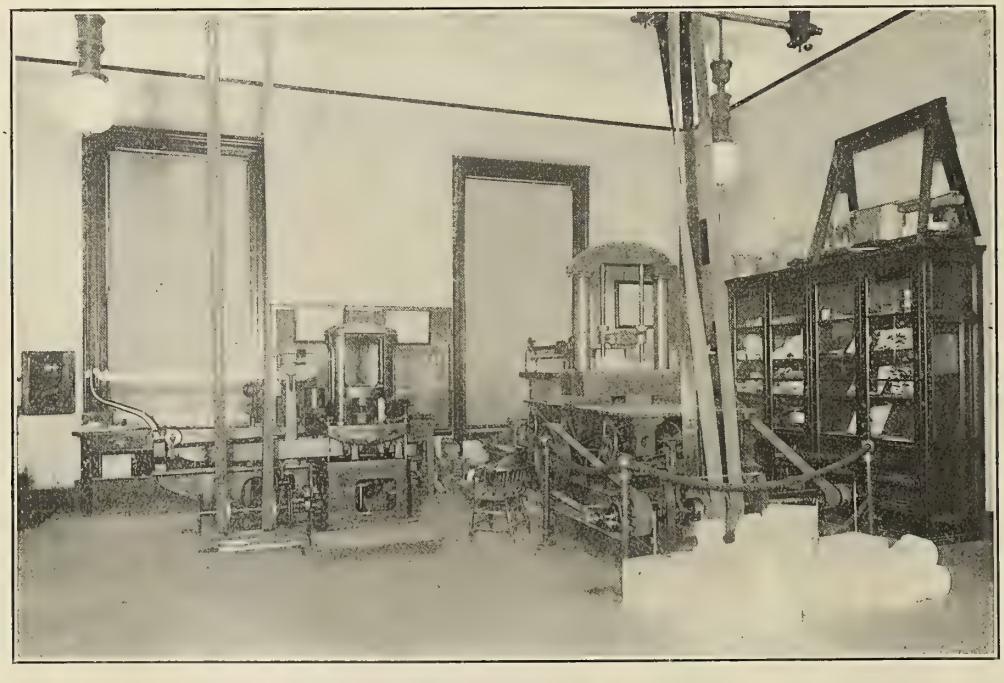
compound, and triple-expansion engines of various types. There is also a variety of air compressors, so that one-, two-, or three-stage compression can be studied.

In connection with the steam engineering laboratory is a large hydraulic laboratory, containing a great variety of pumps and pumping engines. These pumps are of different designs, and are



THE ELECTRIC TESTING LABORATORY.

for pressures ranging from a few pounds to five thousand pounds per square inch. Large tanks are provided so that the feed and discharge can be accurately measured, and these tanks can also be fitted up for special experiments. There is also a section of the laboratory devoted to internal combustion engines. Here



LABORATORY FOR TESTING MATERIALS OF CONSTRUCTION.

various types of engine are installed, and among others there is a two-cylinder, gasoline-boat engine with all details of gasoline tank, carburetor, muffler, and ignition battery.

The drawing and design courses are carried on in the large drawing rooms, which are located on the upper floors of the engineering building. These rooms are splendidly lighted, having very large windows and a good supply of arc electric lights for use on dark days. In connection with the drawing rooms, there is a carefully selected reference library, containing certain trade publications and technical papers which are not found in the main library of the university. In this library are also kept blue-prints, photographs, and drawings for illustrating points in ship and engine construction. This collection is already quite extensive and is being constantly enlarged.

During his first two years, the student is required to take courses in shop work, which are further extended by two summer classes, so that he will derive the advantages possible from continuous work in the shop. Then, in connection with his marine work, visits are paid by the student to the various yards where vessels are under construction, and he sees the processes which are peculiar to shipbuilding. As the students are accompanied on these visits by the professor in charge of the course, the time is spent in seeing and learning the useful points, rather than in sight-

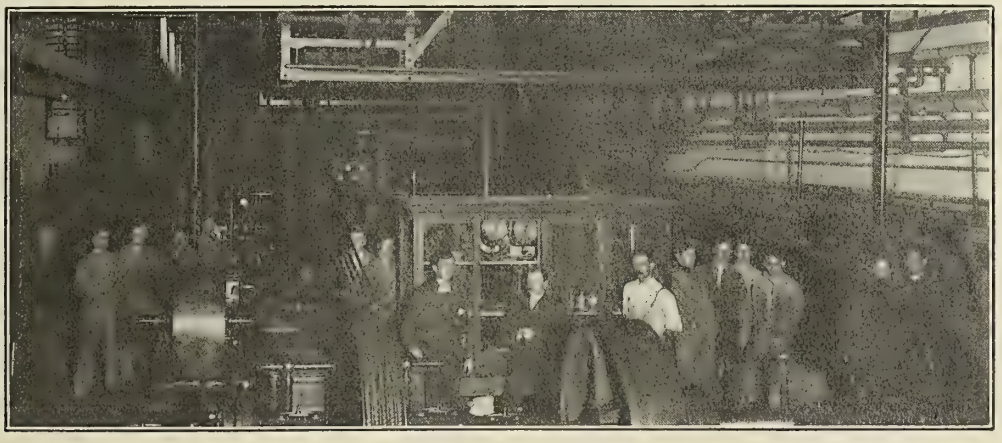
seeing. The different kinds of riveted work are particularly studied on these visits. Considerable attention is also paid to the order in which the material is put into the ship, and the methods of handling the material. As almost all the methods of handling material now in use can be found at one yard or another in the vicinity, this problem can be studied very thoroughly. In some of the smaller yards much of the material is still handled by derricks and gin-poles, while the most modern methods of handling with cranes are found in others, such for instance, as the Brown cantilever crane on an elevated runway, which is in use at the Brooklyn navy yard.

Wherever it is possible, attention is called to the different ways of doing various things, such as making plating joints. Such comparisons as are possible are made, and the students are required to make rough calculations of the various items so as to impress them on their minds. An illustration of this is: after explaining how a deck is laid with joggled plates and an example of this method has been studied, count the number of tapered liners that have been omitted and estimate the weight saved by the use of the joggled plates. Attention is also called to the fact that the liners must be put in place, marked, returned to the shop and punched, before they are ready to be finally placed. This indicates to the student the items to be considered in estimating the cost of the two systems. These inspection visits are of great value in assisting him to apply the principles he has studied to actual conditions, and are made as frequently as possible. Some of the trips are to vessels in the harbor, instead of to the building yards, in order to study different kinds of ships and see what are the best types of each particular service. It is also possible on these trips to compare the products of the various shipbuilders, American and foreign.

The marine course at Columbia is especially broad, and yet each subject is taken up so thoroughly as to avoid inculcating habits of superficiality. As this latter point is particularly to be avoided, frequent quizzes are given in all the studies, and the students are required to pass a final examination in each subject, to insure their understanding it thoroughly. By this method the instructor knows, at any time, what each student is doing, and the students are able to know what progress they are making.

ONE CORNER OF THE MARINE DRAWING ROOM.

In the more purely marine subjects, the course in theoretical naval architecture runs through the entire fourth year, and treats of the following: Methods of calculating areas and volumes as applied to ship forms; displacement; moments of areas and volumes; center of buoyancy; metacenters; statical stability; center of gravity; dynamical stability; trim and moment to alter trim; stability in damaged condition; stability in launching condition; theory of waves; rolling of ships; strains experienced by ships; strength of ships; steering.



THE MECHANICAL LABORATORY.

The course in ship calculations is carried parallel with the naval architecture, and includes the working out of a displacement sheet and the usual curves of tons per inch of immersion, stability, buoyancy, and the equivalent girder. In making these calculations, the student becomes familiar with the use of the mechanical integrator and planimeter. The course in marine engine and boiler design covers the principles of such design work, and these are emphasized by the working out of the engines, boilers, condensers, etc., for the ship treated in the other courses.

The course in shipbuilding is principally a course in ship drafting. In this a set of lines is first drawn and faired. The midship section is then drawn according to Lloyd's rules, or the rules of a similar classification society. This section is then studied with a view to improvement, and, if possible, is strengthened by simply rearranging the material. Its strength is then considered in comparison with the maximum bending moment that the ship might encounter. After the midship section is complete, the inboard profile and deck plans are drawn, the boilers and engines being put in which have been calculated in the engine design course. In making these drawings, the students become familiar with the rolled steel sections used in ship work, as well as with the methods of designing ships. Special attention is also given to the use of standard fittings in this design work, and the students are encouraged in criticizing the design of fittings that they find on drawings of other ships. Merchant work is taught almost exclusively in this course, because it is not considered advisable to teach the students the costly type of construction used on naval vessels at the beginning of their professional careers.

The course in propulsion treats of the kinds of resistance; the relative value of the different resistances; the law of mechanical similitude; the powering of ships; propeller design. The last subject is very thoroughly covered by problems.

The marine seminar consists chiefly in the reading and discussion of reviews, written by the students, of articles in the technical papers. This exercise has a manifold value. It not only makes it necessary for the student to read the article assigned, but he must also look up the whole subject, as far as his time permits. He also hears the reviews of the articles assigned to other students, and the discussion of them. More important than either of these, it gives him training in expressing himself, and practice in analyzing technical subjects.

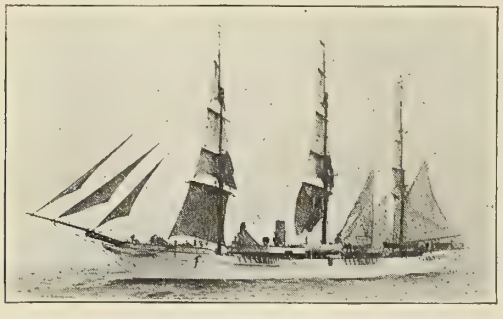
Before receiving his degree, the student is required to submit an acceptable thesis. This can be on any subject which has a close relation to the work of his course, and may consist of an analytical discussion of some problem, an experimental determination of some fact, or a design of some vessel or part of a vessel. The work on this thesis must, however, be original, and nothing that is simply copied from the writings of others will be accepted.

As the training for a naval architect or a marine engineer is so closely allied to that for a mechanical engineer, the courses outlined above are based on the mechanical engineering course that was in existence when the marine courses were organized, and the degree given for the latter is that of mechanical engineer. The university also offers a number of courses which lead to higher degrees, and which are particularly valuable to either a naval architect or a marine engineer.

APACHE.

HILDEGARDE.

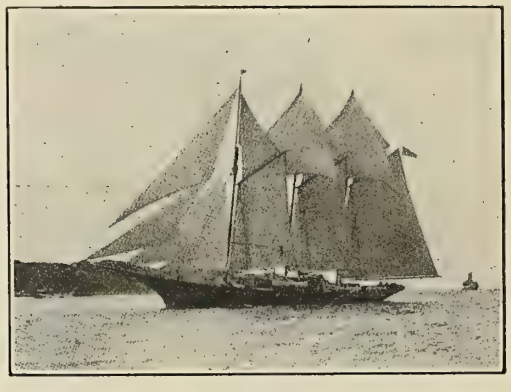
SUNBEAM.



VALHALLA.

The International Ocean Yacht Race.

Early in the evening of the 29th of May, the three-masted schooner-yacht *Atlantic*, belonging to Mr. Wilson Marshall, designed by Mr. William Gardner, and built by the Townsend-Downey Shipbuilding Company, crossed the line south of the Lizard lighthouse in England, and thereby won the race for the cup offered by the Emperor of Germany. The time of the *Atlantic* was very fast, she having occupied on the passage but 12 days 4 hours and 1 minute for a total of 3,028 miles. This gives a speed from start to finish of about 10.5 miles per hour, which figure would have been considerably increased had it not been that a calm resulted in her occupying about 12 hours in covering the distance from the Scilly Islands to the Lizard.

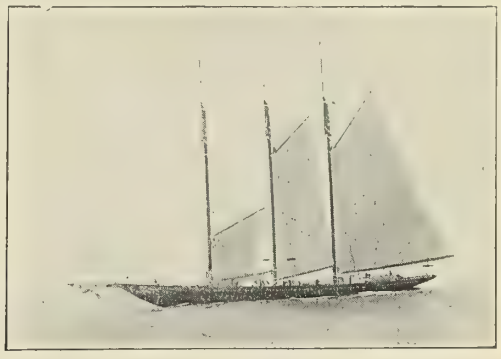


UTOWANA.

The German schooner-yacht *Hamburg*, which was the second to finish, covered a distance of 3,093 miles in 13 days 2 hours and 6 minutes, being thus 22 hours and 5 minutes longer on the trip than was the *Atlantic*. Her speed was 9.85 miles per hour. The English ship-rigged *Valhalla*, and the American schooner *Endymion* finished third and fourth respectively, and thus took the

HAMBURG.

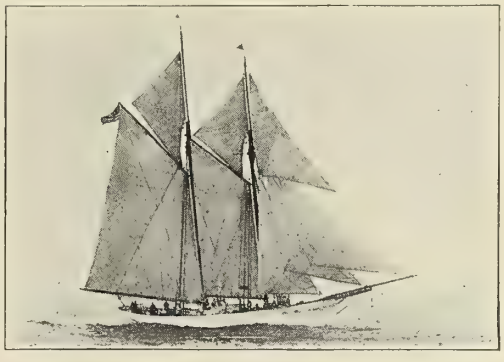
THE CUP.



ATLANTIC.

prizes corresponding with those positions. The other yachts entered in the race finished in the order given in the appended table, which gives their time at the finish, the elapsed time from the start, and the margin which the *Atlantic* had over each of them.

ENDYMION.



FLEUR DE LYS.

One very noteworthy feature in connection with the finish of this race was that the first nine of the eleven yachts crossed the line between 7:15 P.M. and 5:15 A.M. In other words, only the last two finished the race in full daylight. Another noteworthy feature is the fact that although the *Ailsa* finished more than half an hour ahead of the *Utowana,* yet the difference in starting time was such that the elapsed time of passage on this 3,000-mile trip was just one minute greater for the *Utowana* than for the *Ailsa.*

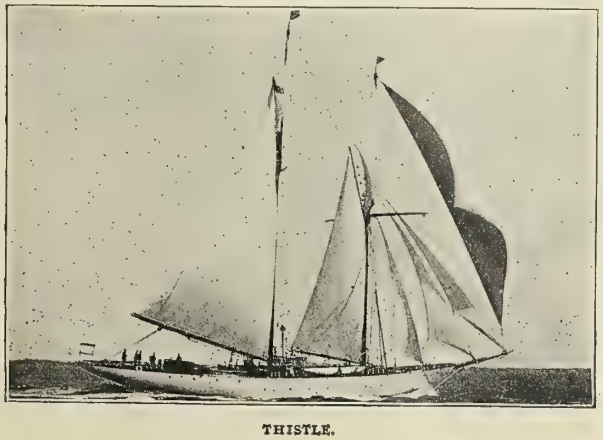
Our illustrations are from *Literary Digest.*

No.	Yacht.	Start, May 17.	Finish.	Elapsed Time. d. h. m.	Lead of Atlantic. d. h. m.
1	Atlantic.....	12.16 P.M.	May 29, 9.17 P.M.	12 4 1	.. .. ..
2	Hamburg.....	12 17 "	" 30, 7.23 "	13 2 6	0 22 5
3	Valhalla.....	1.05 "	" 31, 8 08 "	14 2 3	1 22 2
4	Endymion	12 17 "	" 31, 9.34 "	14 4 17	2 0 16
5	Hildegarde....	12.15 "	" 31, 10.08 "	14 4 53	2 0 52
6	Sunbeam.....	12.32 "	" 31, 11.40 "	14 6 8	2 2 7
7	Fleur de Lys ..	12.27 "	June 1, 2.48 A.M.	14 9 21	2 5 20
8	Ailsa.....	12.15 "	" 1, 4.25 "	14 11 10	2 7 9
9	Utowana	12.55 "	" 1, 5.06 "	14 11 11	2 7 10
10	Thistle.....	12.18 "	" 1, 12.45 P.M.	14 19 27	2 15 26
11	Apache.....	12.35 "	" 5, 10.20 A.M.	18 17 5	6 13 4

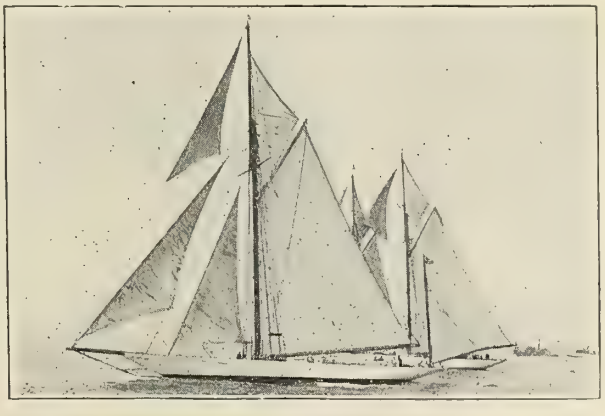
Early Ferryboat Expenses.

In the Engineers' Club of New York is the original of a letter written by Robert Fulton, and dated January 22, 1810, which gives an interesting estimate of the cost at that time of operating a ferryboat, the estimate being made for one year as follows:

"Two firemen at 30 dollars a month each, they finding themselves, they will also act as engineers to keep the engine in order, they must be engaged for the year, as such men cannot be turned away in the winter and got in the spring = 60 dollars a month—	$720.00
"Two Boatmen to take turns in steering at 25 dollars a month each, 50 dollars a month,	600.00
"1½ Cords of wood for 12 or 13 hours at 4½ dollars a cord, or say 7 dollars a day to work 320 days	2240.00
"Ware tare and Repairs	600.00
"Total	$4160.00"



THISTLE.



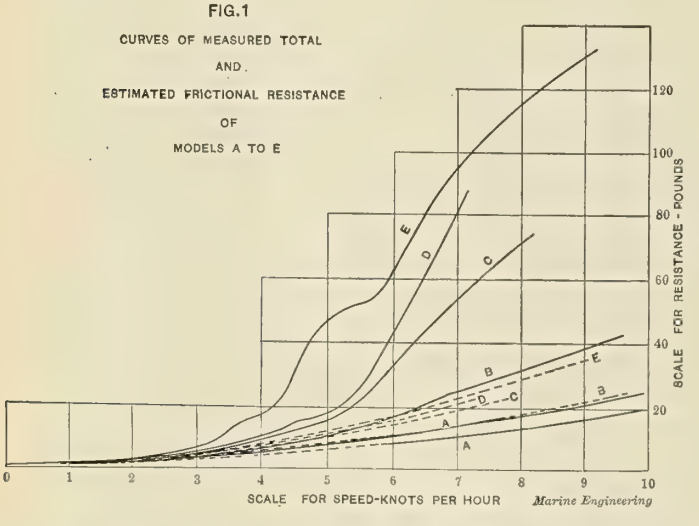
AILSA.

LAWS OF VARIATION OF RESISTANCE OF SHIPS.

BY D. W. TAYLOR, U.S.N.

For many years, until knowledge of experimental results obtained at model basins became disseminated, naval architects sought some simple formula expressing the resistance of a given ship as a function of its speed. The so-called "Admiralty coefficients" were based upon the assumption that the resistance of a ship varies as the square of its speed. Many other formulæ, some of them very complicated, have been proposed. Analysis of model basin experiments soon shows that the assumption upon which the "Admiralty coefficients" are based is radically in error, except for very low speeds, and that there is no possible simple formula covering the ground; that is to say, it is impossible to adequately express the resistance of a ship by a simple formula such as $r = cV^n$, where r is resistance, V is speed in knots, and c and n are constants. It is possible at any point on the curve of resistance to determine values of c and n, such that a curve drawn with these values touches the curve of resistance at the chosen point, but these values of c and n change rapidly and radically with speed.

Fig. 1 shows curves of total resistance as determined by experiment and of estimated frictional resistance, for five models, A, B, C, D, and E, whose characteristics are given in Table 1. The curves in full lines are the actual curves of resistance of the models. The curves in broken lines are the curves of estimated frictional resistance of the models. It is evidently absurd to suppose that lumpy, irregular curves, such as some shown in Fig. 1, can be adequately represented throughout any large portion of their length by the formula $r = cV^n$. Three of the models referred to in Table 1 are of actual vessels, A being a torpedo boat, B a destroyer, and D a cruiser. Model C was on the lines of an actual cruiser with modified dimensions, and model E was from a design of a 600-foot collier of 21,000 tons displacement, with a



parallel middle body extending for 260 feet. This model, of course, was not adapted to high speeds, the actual intended speed being 14 knots, and the corresponding speed of the model as indicated in Table 1 being but 2.55 knots. It will be noted from Fig. 1 that all of the curves extend to higher speeds than the corresponding speeds of the actual ships. From the curves of Fig. 1 there have been calculated the values of the index n in the formula $r = cV^n$ above, and the results are plotted as curves in Fig. 2. These results show the impossibility of using any simple formula such as $r = cV$. Curves of c corresponding to the curves of n of Fig. 2 would be still more erratic than the curves of n. It must not be supposed that the anomalies of Fig. 2 are accidental. They are characteristic. Such curves for any models taken at random would show similar anomalies.

Returning to Fig. 1, we observe that the curves show a number

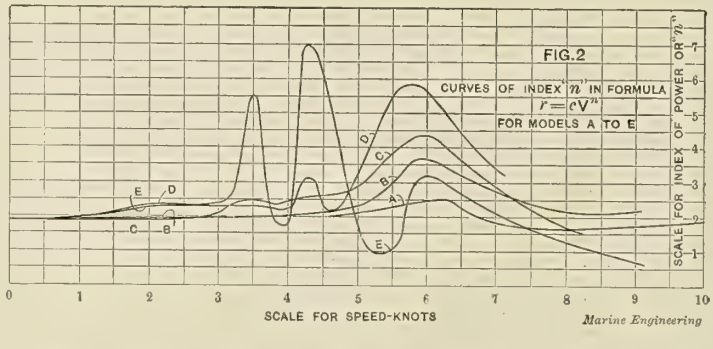
TABLE I.—DIMENSIONS, ETC., OF MODELS A TO E.

Model	A	B	C	D	E
Displacement of model in pounds	316	533	1140	1558	1694
Length of model in feet	20	20	20.6	20.32	20
Beam of model in feet	1.504	1.876	2.676	2.328	2.076
Mean draught of model in feet	.455	.562	.670	.950	.863
Area of midship section, square feet	.4455	.7354	1.545	2.113	1.734
Midship section coefficient	.651	.697	.8616	.9554	.9678
Block coefficient	.3694	.404	.493	.5548	.756
Cylindrical coefficient	.5674	.579	.573	.581	.781
Corresponding speed knots*	9.37	8.15	4.94	4.42	2.55
Value of $\frac{V}{\sqrt{L}}$ for designed full speed	2.095	1.822	1.104	.988	.570
Value of $\frac{D}{\left(\frac{L}{100}\right)^3}$	17.63	29.74	58.22	82.89	94.53

* This is speed of model corresponding to designed speed of full size vessel.

of humps and hollows, the maxima of Fig. 2 corresponding to the humps and the minima to the hollows. These humps and hollows are due simply to the favorable or unfavorable conjunction of the two systems of waves naturally set up, one at the bow and the other at the stern of the model. In the case of a full model these waves are appreciable at low speeds, and hence we find a hump at the speed of 3 3-4 knots for a 20-foot model. There is then a hollow, followed by a marked hump at about the speed of 4 1-2 knots, succeeded by a hollow, and a final hump at a speed a little over 6 1-2 knots. The latter hump corresponds to the condition of affairs when there is a wave crest at the bow, the bulk of the vessel is in the succeeding hollow, and the second crest of the bow wave system appears abaft the stern, where it reinforces the stern wave. Evidently, beyond this speed there can be no further hump, since there is no other wave crest to move aft with increasing speed and reinforce the stern wave. For all speeds beyond this hump the ship is traveling on the back of the bow wave, so to speak.

For very fine models, such as A and B, the low-speed humps and hollows are not appreciable for the reason that at the speeds at which they are due to appear the wave disturbances made by fine models are very slight. For such models, 20 feet long, the



6 1-2-knot hump is the only one which appears in practice, and even that is not usually very strong. For 20-foot models pushed to a speed of about 14 knots there is a curious kind of small secondary hollow, the cause of which is not clear. As we make a model more and more bluff, the 4 1-2-knot hump assumes more and more prominence, until for models with cylindrical coefficients above 0.625, it is usually very strong. There is one curious fact which is exemplified in Fig. 1, which is, that for each model, as a rule, there is but one very pronounced hump. For a full model the 4 1-2-knot hump is very pronounced, whereas the 6-knot hump is relatively much less prominent. For fine-ended models, however, the 4 1-2-knot hump may be hardly perceptible, but the 6-knot hump much stronger than for the full-ended models. Hence, for vessels intended to be driven at speeds in the neighborhood of the 4 1-2-knot hump it is very favorable to speed to make the ends fine. This reduces the 4 1-2-knot hump and amplifies the

6-knot hump. The above fact is one having great influence upon the preferable shape for high-speed torpedo boats and destroyers, for which the corresponding speed of a 20-foot model is greater than 6 knots.

Accepting the fact that the formula $r = cV$ cannot adequately represent the resistance of a vessel, the question arises whether we can find some approximate method or formula of value in practice, or must rely only on model-basin experiments. The method pursued in the model basin may be summarized as follows: From the total resistance of a model at a certain speed we deduct the skin or frictional resistance of a surface of area the same as that of the immersed surface of the model driven through still water at the speed in question. To the remaining resistance of the model, which we call the residuary resistance or wave resistance, since it is practically all wave resistance, we apply the law of comparison and deduce the residuary resistance of the full-sized ship at the speed corresponding to that of the model. We then calculate the frictional resistance of the full-sized ship. It is seen then that even when using model-basin experiments we calculate from tabular data the skin friction of the full-sized ship, using Froude's or Tideman's coefficients. Fig. 3 shows Tideman's coefficients for smooth steel surfaces of ships, plotted upon logarithmic intervals of speed as straight lines, showing the frictional resistance in pounds per square foot of wetted surface for vessels of any length and speed. Froude's coefficients give slightly less friction than Tideman's, but it is thought that for ordinary ships, and especially for estimating purposes, Tideman's results are preferable. In order to use Fig. 3 we need to know the wetted surface of the ship in square feet. A close approximation to the wetted surface of the hull proper of a given vessel of length on water-line in feet $= L$ and displacement in tons $= D$ may be obtained from the formula $S = 15.5\sqrt{DL}$, where S is wetted surface in square feet. This formula does not apply to very broad, shallow vessels whose beam is over 3 1-2 times the mean draft. If it is desired to allow a small margin for appendages to hull proper, etc., we should use $S = 16\sqrt{DL}$. Since, then, we can calculate closely the skin friction of a ship, we need an approximate method for the determination of residuary or wave-making resistance only. A full discussion of residuary resistance will be found in works on naval architecture. Rational formulæ

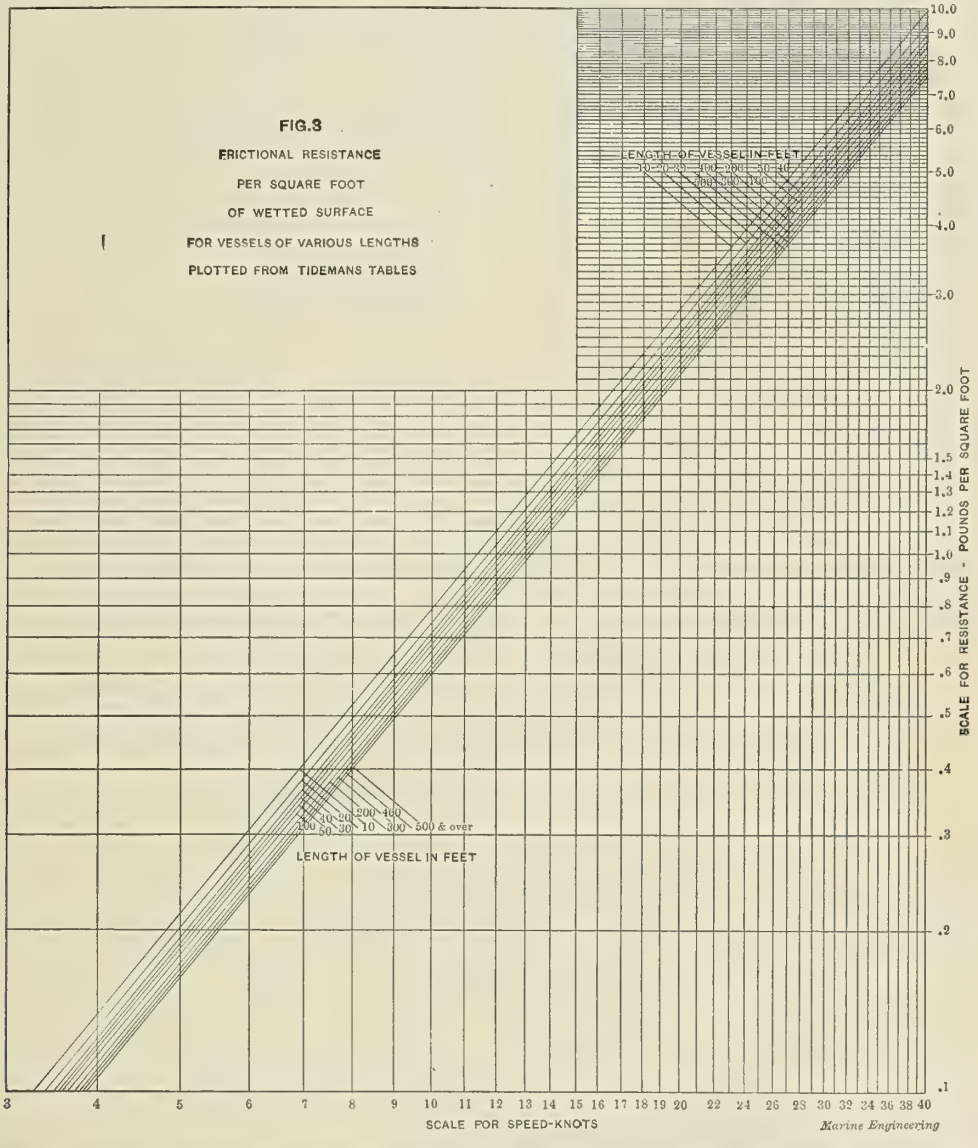


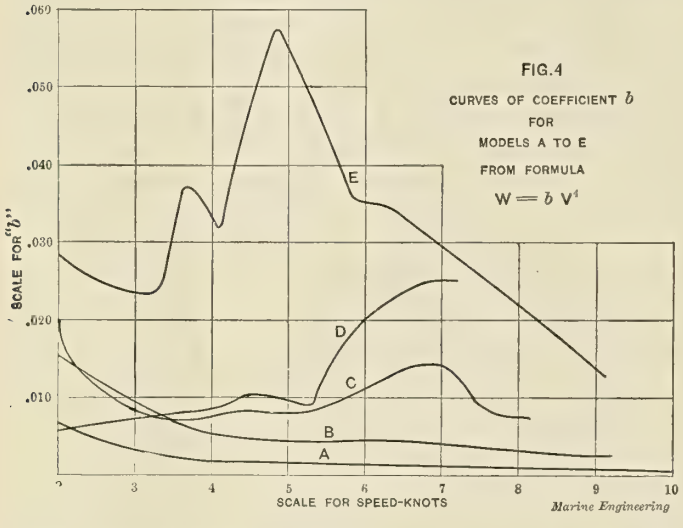
FIG.3
FRICTIONAL RESISTANCE
PER SQUARE FOOT
OF WETTED SURFACE
FOR VESSELS OF VARIOUS LENGTHS
PLOTTED FROM TIDEMANS TABLES
LENGTH OF VESSEL IN FEET
10-20-30-40-50-60-70-80-90-100-200-300-400-500 & over
SCALE FOR RESISTANCE - POUNDS PER SQUARE FOOT
10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.5 1.4 1.3 1.2 1.1 1.0 .9 .8 .7 .6 .5 .4 .3 .2 .1
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 22 24 26 28 30 32 34 36 38 40
SCALE FOR SPEED-KNOTS
Marine Engineering

for this resistance would be of the form $W = bV^4$, where W is the residuary resistance, V the speed in knots, and b a coefficient which for moderate speeds may be expected to oscillate about an average value, and for high speeds to steadily fall off. Fig. 4 shows for the residuary resistances of Fig. 1 curves of values of b. The maximum values of b of course correspond to the humps of the curves, and the minimum values to the hollows. It is seen that for model E there is a notable hump in the curve of b at a speed somewhat under 5 knots. For models C and B the notable maximum corresponds to the 6 1-2-knot hump, while for the fine models the coefficient falls off all the way. It should be pointed out, however, that for speeds below 3 knots the actual residuary resistance is very small, and it makes very little difference what the value of b may be.

Of course, the coefficient b above depends upon the dimensions,

proportions, and shape of the vessel. In "Resistance and Propulsion" a number of years ago the writer suggested using for b $b_0 \times \frac{D^{\frac{2}{3}}}{L}$. Then b_0 does not change with change of dimensions of similar vessels, although it would change with change of proportion and shape.

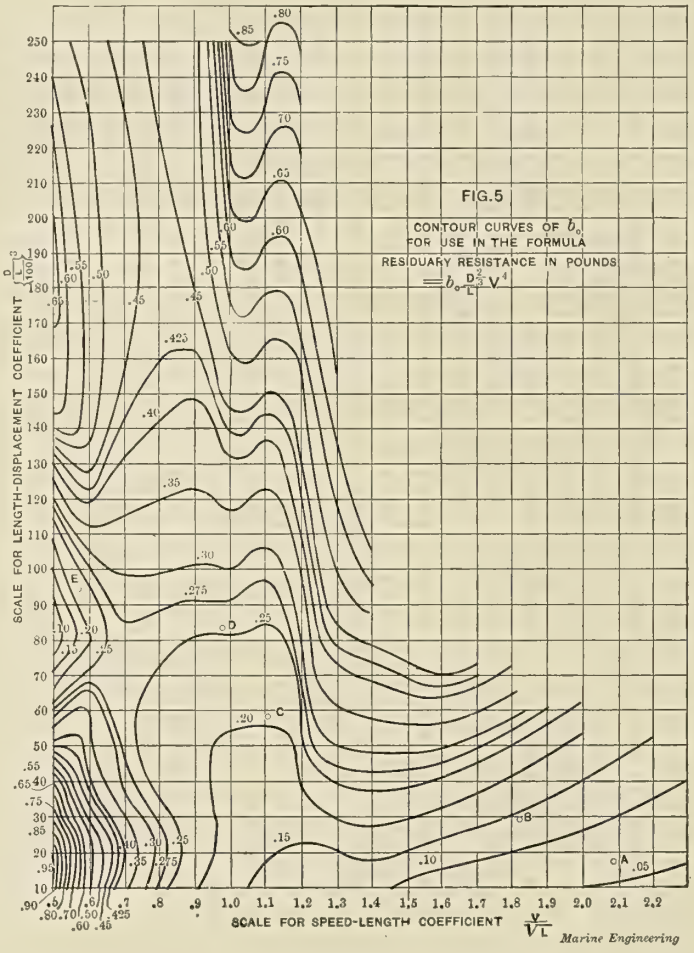
Investigation of values of b_0 from results of model experiments indicates that, broadly speaking, the length and displacement are the primary factors affecting the residuary resistance. This, of course, applies to well and fairly shaped models. The resistance of a square-ended scow of a given length and displacement would be enormously greater than that of a fair ship of the same length and displacement. Considering fair models, however, of ordinary types, it is quite evident from model-basin results that the length adopted for a given displacement has, broadly speaking, a much more powerful influence upon the wave resistance at a given speed than ordinary variations of fineness, of proportions of beam to draft, etc. This does not mean that fineness of a vessel of given length and displacement does not affect the residuary resistance, but that the effects of such variations of fineness as would ordinarily be found in designs by different naval architects are rather secondary as compared with the effect of length for displacement. Without discussing the question fully, it may be remarked that when $\frac{V}{\sqrt{L}}$ is not greater than 0.8 very large variation of block coefficient appears to produce little effect upon the resistance of a vessel. The block coefficient may vary from 0.55 to 0.66 or more



without serious change of resistance. Above $\frac{V}{\sqrt{L}} = 0.8$, however, the effect of the fineness rapidly increases. A model of block coefficient above 0.55 can be driven to a speed $\frac{V}{\sqrt{L}} = 1$ only by a disproportionate expenditure of power, and for higher speeds still the block coefficient should not exceed 0.5.

When plotting results for general application it is advisable, instead of using the actual speed of a vessel, to use the actual speed divided by the square root of the length. This makes comparable results from ships of various lengths. The phenomena of the humps and hollows occur at almost constant values of $\frac{V}{\sqrt{L}}$, whereas, if the curves of vessels of varying lengths were plotted upon their speeds only, these phenomena would of course occur at different speeds.

Fig. 5 shows contour curves of values of the coefficient b_0 above, plotted upon values of $\frac{V}{\sqrt{L}}$ as abscissæ and values of $\frac{D}{\left(\frac{L}{100}\right)^3}$ as ordinates. These contour curves express average results obtained from a large number of models, and, while by the use of Fig. 5 we cannot expect to obtain more than a rough approximation to the residuary resistance in the case of any given vessel, this figure represents with fair accuracy the nature of the broad features of variation of residuary resistance for ordinary vessels without parallel middle body. No models of speed launches were used in obtaining Fig. 5, and for such an extreme type of vessel, or any other extreme type of vessel, Fig. 5 cannot be depended upon to give a close approximation. For actual application Fig. 6 is more convenient than Fig. 5. Instead of curves of the coefficient b_0 this gives curves of resistance in pounds per ton of displacement throughout the range of speed and displacement likely to be needed for vessels of ordinary types. The application of this figure in practice is comparatively simple. Taking a vessel of given dimensions and displacement, the value of $\frac{D}{\left(\frac{L}{100}\right)^3}$ is a constant, and values of $\frac{V}{\sqrt{L}}$ for any desired speeds



are readily calculated. Entering Fig. 6 with a constant value of $\frac{D}{\left(\frac{L}{100}\right)^3}$ we take off for as many values of speed, or $\frac{V}{\sqrt{L}}$ as desired the residuary resistance in pounds per ton, interpolating as necessary; and knowing the displacement in tons, calculate the total residuary resistance. Then calculate the frictional resistance from Fig. 3. Adding together the frictional and residuary resistances the total resistance for a given speed is obtained. I should again repeat that Fig. 6, deduced as a kind of average from results of a large number of models, must be regarded simply as a rough approximation.

Figs. 5 and 6 are really the same. In fact, Fig. 5 was obtained from the curves of Fig. 6. The eccentricities of the coefficient b_0 shown in Fig. 5, are more apparent than real. The large values occurring in the lower left-hand corner of the diagram are of no

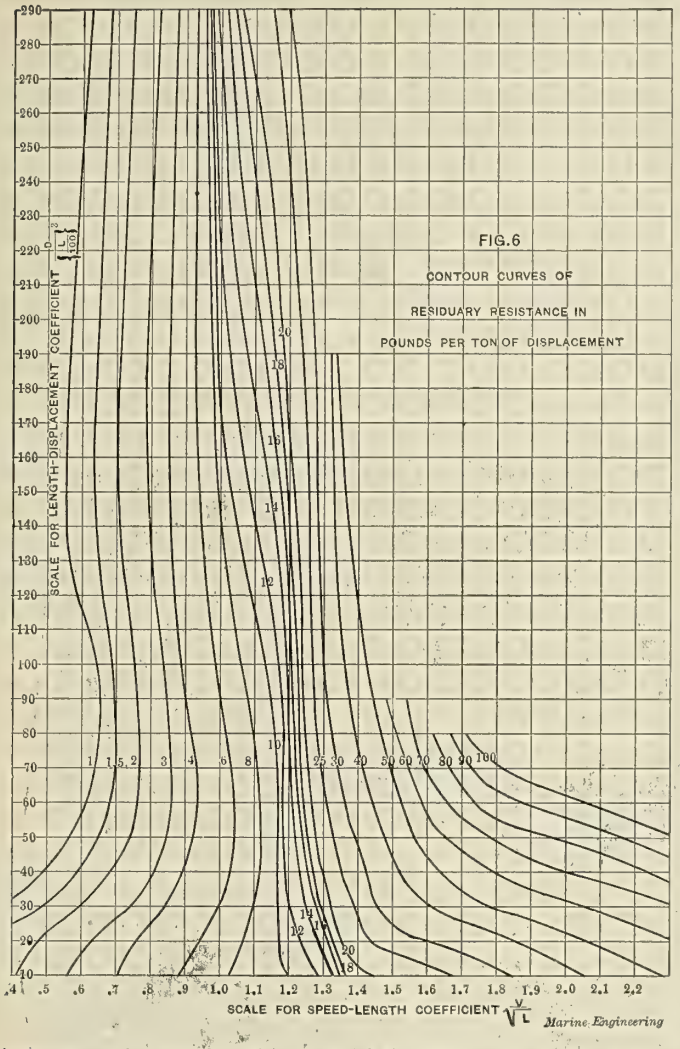

SCALE FOR LENGTH-DISPLACEMENT COEFFICIENT $\frac{D}{\left(\frac{L}{100}\right)^3}$
SCALE FOR SPEED-LENGTH COEFFICIENT $\frac{V}{\sqrt{L}}$
Marine Engineering

FIG.6
CONTOUR CURVES OF
RESIDUARY RESISTANCE IN
POUNDS PER TON OF DISPLACEMENT

importance in practice, that part of the diagram referring to low speeds of vessels which are exceedingly long and fine.

In "Resistance of Ships and Screw Propulsion" the writer attempted to fix approximate values of b_0 from such published results of model-basin experiments as were available fifteen years ago. At that time the fair average value of b_0 which was adopted for moderately fine, high-speed vessels, was 0.4, rising to 0.45 or more for vessels which were broad in proportion to their length, and falling to 0.35 or less for vessels which were long and moderately fine. Bearing in mind that for the vast majority of fast vessels at full speed the speed length coefficient will be found between 0.8 and 1, it is seen that the above values of b_0 are not seriously in error for practical purposes, except for vessels which are exceedingly fine and exceptionally long. For such vessels the coefficient b_0 is small, and, if they are pushed beyond a speed length coefficient of 1.4, the coefficient appears to steadily fall off. On Fig. 5 the lettered spots indicate the values of $\frac{D}{\left(\frac{L}{100}\right)^3}$ and of $\frac{V}{\sqrt{L}}$ at maximum designed speed for the five models A to E.

Fig. 7 repeats in full lines the original resistance curves of total resistance of models A to E of Fig. 1, and shows also by broken lines the corresponding curves as calculated from Figs. 5 or 6, the frictional resistance being taken as the same in each case. It is seen that the calculated curves follow the actual curves reasonably closely throughout, except in the case of model E. This illustrates the fact that Figs. 5 or 6 are to be regarded as rough approximations to facts for actual vessels of usual type, but are of little or no use when applied to extreme or impossible types of vessels. The speed of model E, corresponding to the actual designed speed of the vessel, was but 2.55 knots, while in Fig. 7 the resistance is shown for a speed as high as 9 knots, corresponding to about 49 knots for the full-sized vessel. Of course, no one would design such a vessel with a cylindrical coefficient of 0.781 to be driven at high speed. It will be noted that the displacement of model E is not much greater than that of model D, the latter being properly shaped for a high speed. Figs. 5 or 6 may readily be used to determine the length necessary to obtain the absolute minimum resistance for a vessel of given displacement. Upon doing this it will be found that for a high-speed vessel the length for minimum resistance is in every practical case beyond the length that is desirable, and in most cases beyond the length that is at all practicable. This result, however, is in exact accordance with the facts as determined by model experiments. It is seldom possible in practice in the case of an actual vessel intended to be driven at a speed for which $\frac{V}{\sqrt{L}}$

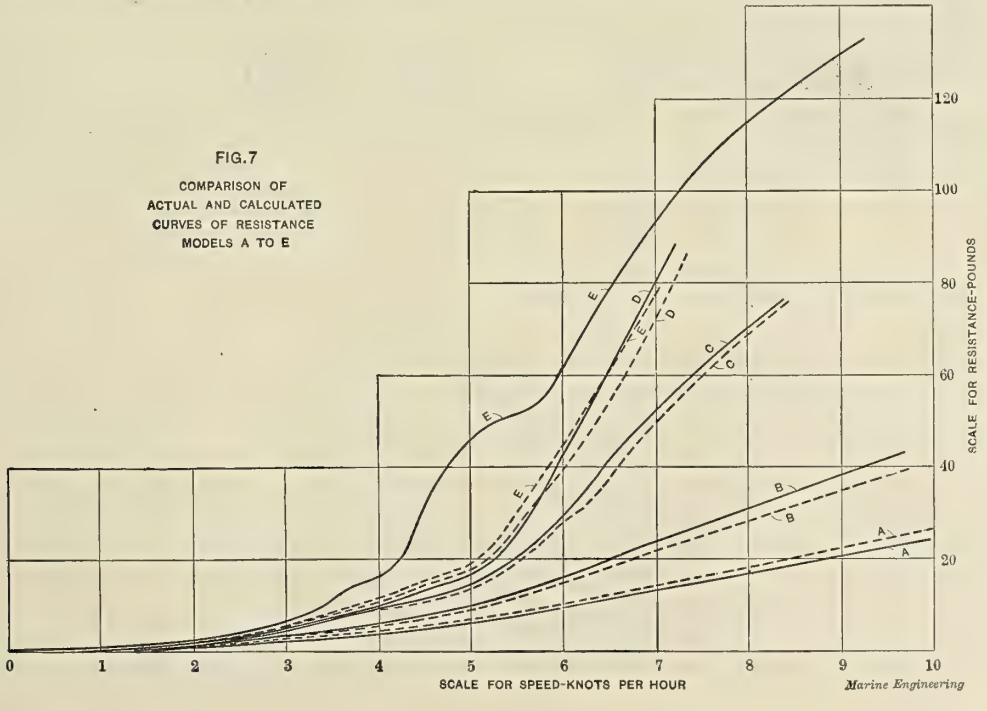


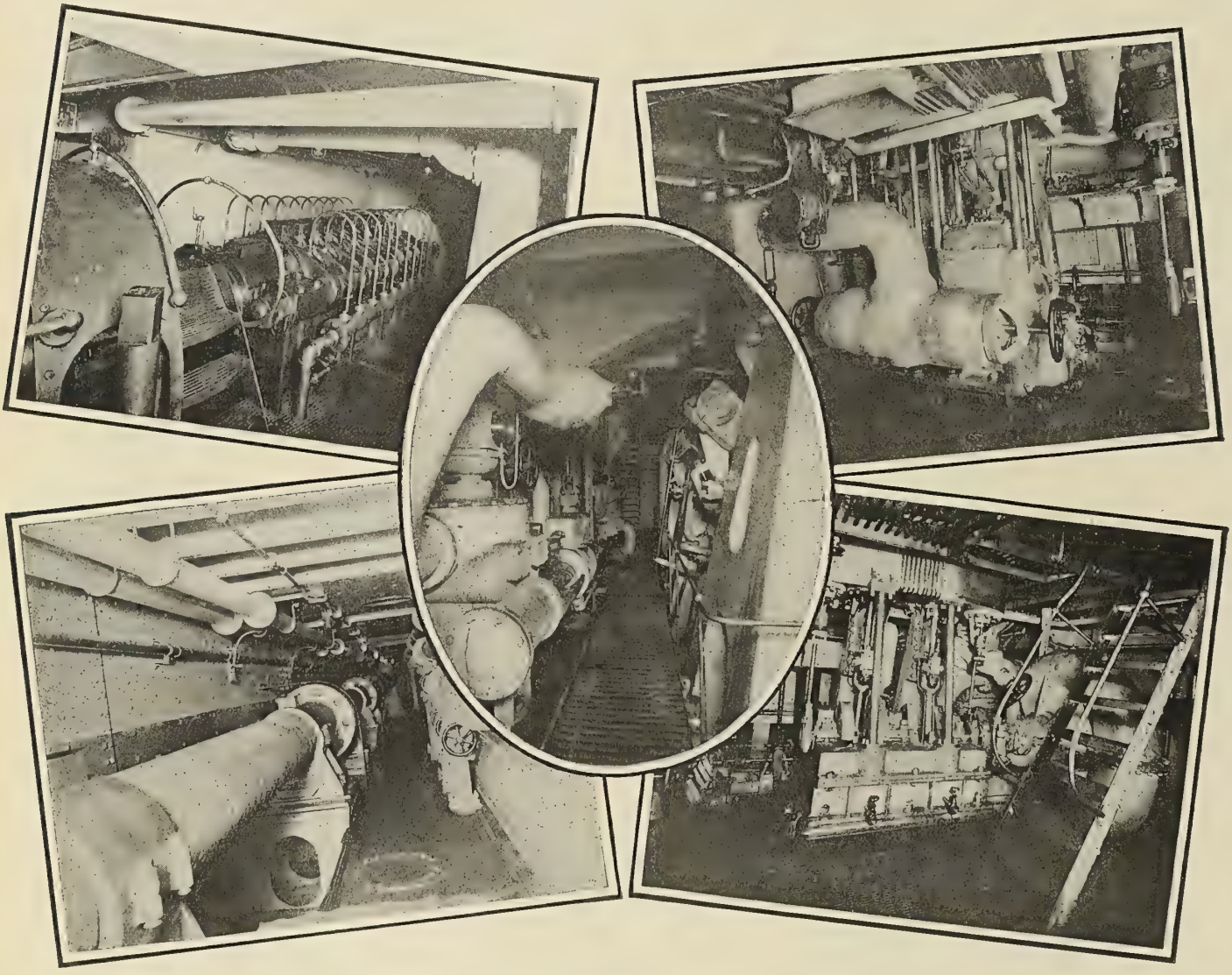
FIG.7
COMPARISON OF
ACTUAL AND CALCULATED
CURVES OF RESISTANCE
MODELS A TO E

= 1 or more to make the length sufficiently great to obtain the very minimum resistance possible.

While by the use of Figs. 5 or 6 and calculation of the skin friction we can expect to obtain only a rough approximation to the actual resistance of a given vessel, the effect of variation of length for a constant displacement can be investigated with more accuracy; and the length which is most desirable, considering not only the question of resistance but the many other features of importance in this connection, can be determined with a good deal of accuracy.

THE MACHINERY OF THE GREAT NORTHERN STEAMSHIP DAKOTA.

This new 20,700-ton steamer, which was described at some length in our June number, is propelled by two sets of three-cylinder, triple-expansion engines, each designed to develop about 4,800 horsepower, and the entire power being designed to give the ship a sea speed of 14 knots. These engines, which are operated under a steam pressure of 230 pounds per square inch, have cylinders measuring 29, 51, and 89 inches respectively in diameter with a common stroke of 57 inches, and operate at a speed of 78



THRUST BEARING. PORT SHAFT ALLEY. | PUMP PLATFORM. | AIR PUMPS. CENTRIFUGAL PUMP.

A New Ship-Repair Yard.

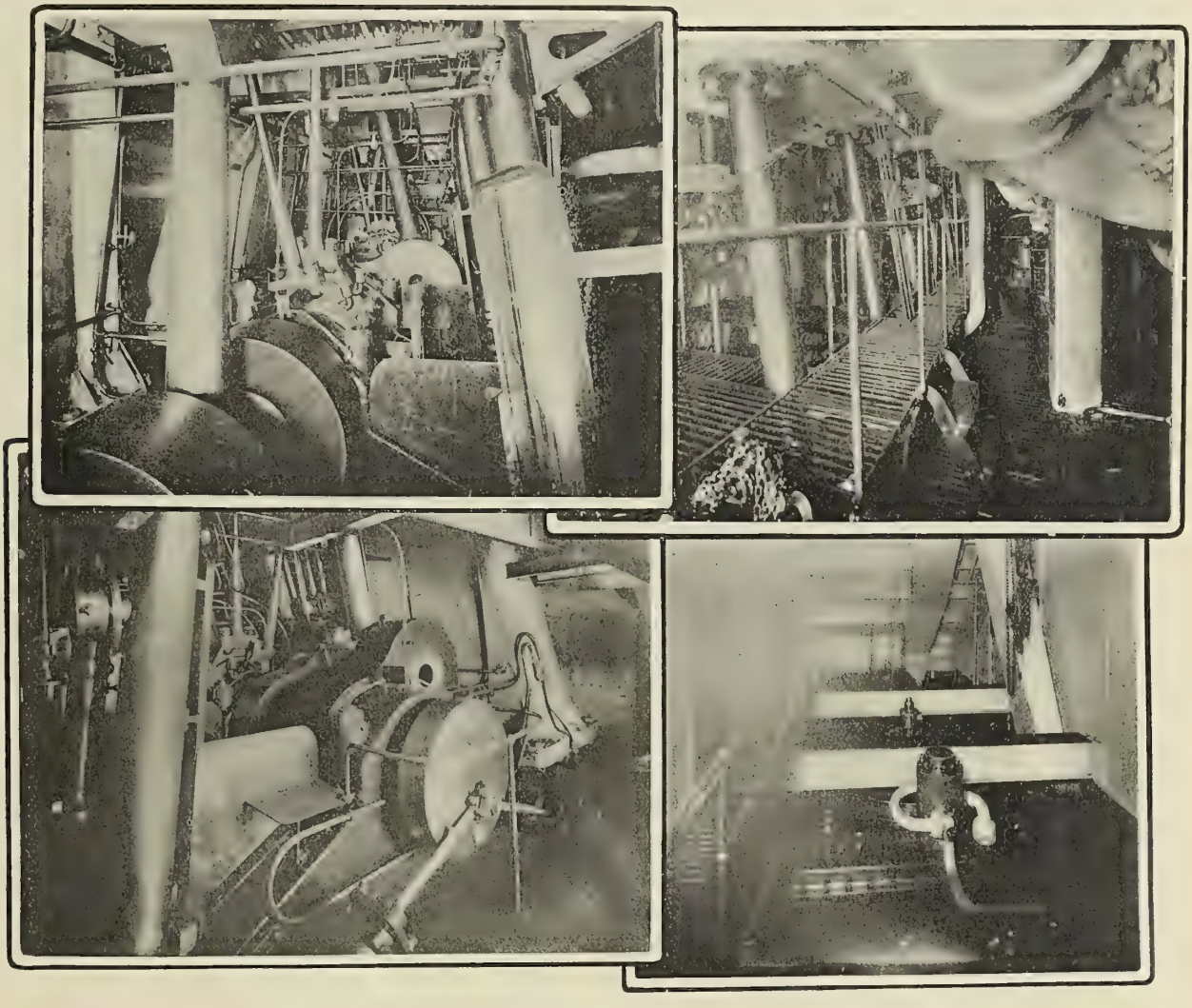
With the arrival in Philadelphia of a section of the floating dry-dock built at Rondout, N. Y., the beginning of facilities for docking ships in that port has been inaugurated, and it is now anticipated that little necessity will be found for sending ships for docking to Newport News or New York. The dock forms part of the equipment of a new concern known as the Philadelphia Ship Repair Company, which will be located at the foot of Mifflin street. It will ultimately be composed of three sections like the present, each capable of lifting 2,000 tons, and all together capable of taking in a ship of considerable size, it being estimated that the largest vessel now navigating the Delaware river could be lifted in the three.

revolutions per minute. The high-pressure cylinder is fed with steam by one piston valve 17 inches in diameter, the intermediate cylinder by a similar piston valve with a diameter of 32 inches, and the low-pressure by a double-ported slide valve 95 inches wide by 59 inches long; all of these valves having a common stroke of 10 inches. The intermediate- and low-pressure valves are fitted with Joy's assistant cylinders, having diameters respectively of 6 3-4 and 8 3-4 inches, while the high-pressure valve is partially balanced by an enlargement in the diameter of the upper portion.

The cylinder castings in each engine are four in number, the low-pressure cylinder and its valve chest being separate castings, while in each of the other cases the valve chest and cylinder are

together in a single casting. The steam opening for the high-pressure cylinder is 11 inches in diameter and steam is drawn in through a steel pipe, while the exhaust opening has a diameter of 15 1-2 inches, and carries the steam through a 15 1-2-inch copper pipe to the intermediate-cylinder valve chest. The intermediate cylinder exhausts through two rectangular passages, each measuring 18 by 12 1-2 inches, while the low-pressure cylinder exhausts through a 32-inch copper pipe into the condenser. All cylinders are steam jacketed, the steam for this purpose being supplied through a 2-inch copper pipe connected with the throttle-valve casing.

an oil cylinder on top, and measures 14 by 7 by 26 3-4 inches. The connecting rods are 10 feet 6 inches long, with a diameter of 10 inches at the crank end and 8 inches at the fork end. The crosshead block measures 13 by 13 inches, with journals 10 inches in diameter and 11 inches long. The slipper, which is of cast steel faced with white metal, measures 24 by 30 inches. The piston rods are 8 inches in diameter in the stuffing box, and taper in the pistons and crossheads to a diameter of 6 inches. Their total length is 10 feet 9 1-8 inches. The pistons are of cast steel and conical in form except for the high-pressure pistons, which are flat and of hollow section in cast iron.



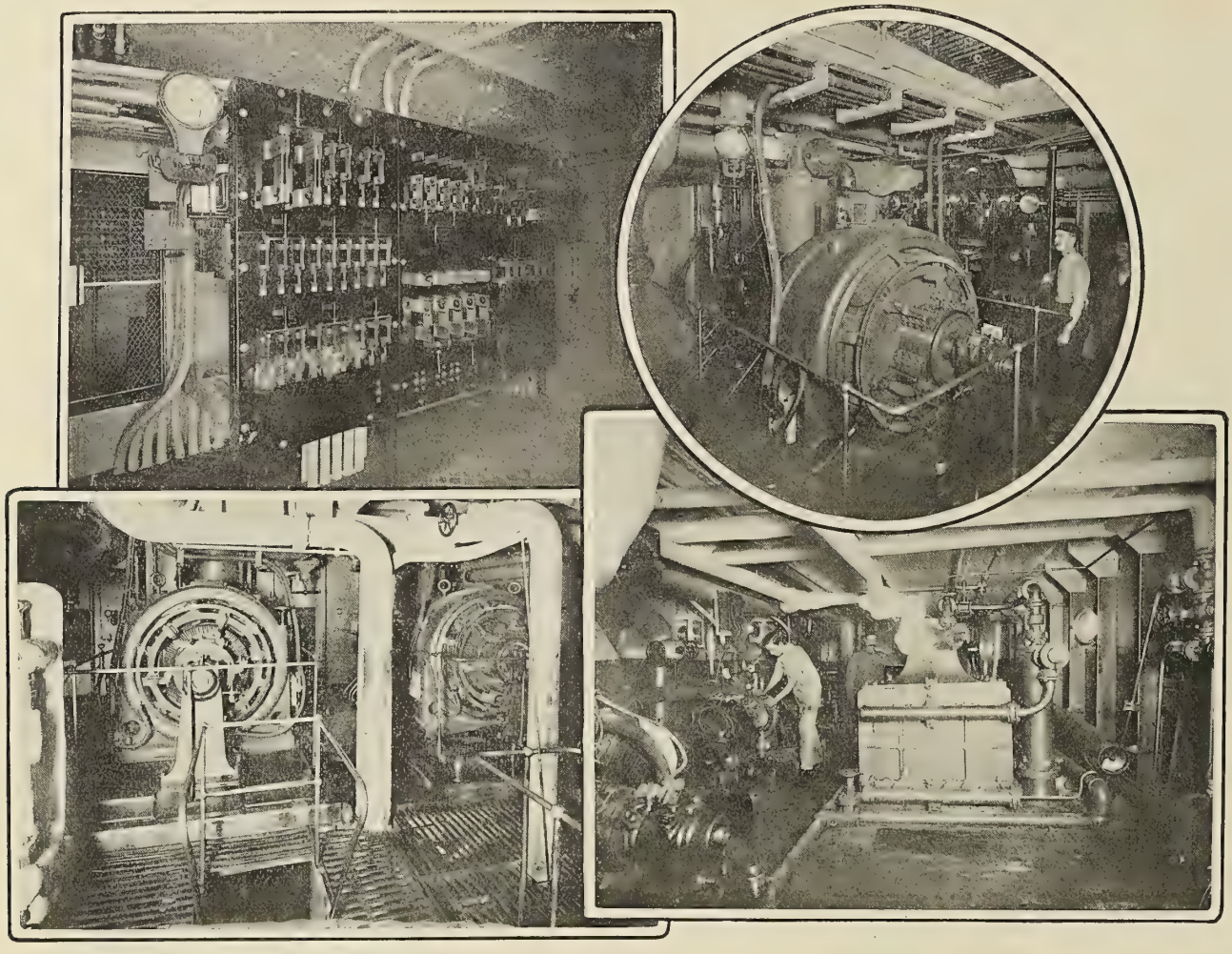
THE MAIN ENGINES OF THE DAKOTA.

The back framing of the engine is of the usual cast iron inverted Y housing, while the front framing consists in each case of six massive steel columns, two for each cylinder. The housings carry the crosshead guides, as well as the gear for handling and governing the engine and for indicating. It has been the intention in designing this machinery to give a maximum of efficiency and endurance at a minimum of weight and cost. With this idea in view the engine framing is of such proportions as to be thoroughly rigid while the engine is in motion, without the use of bracing. The bedplate, which is cast in three sections, is of a very deep box type, the bottom being fitted to the tank top of the ship, to which it is firmly bolted.

The main valves are operated by Stephenson link motion with double bar links and eccentric rods measuring 9 feet 9 inches. The reversing gear consists of a direct-acting steam cylinder with

The crank shaft has been built up in three interchangeable sections, each measuring 10 feet 5 1-2 inches in length, the pins and shaft being 18 inches in diameter with 8-inch axial holes. The webs have a thickness of 12 1-2 inches and a width of 37 1-2 inches, their length over all being 66 inches. The couplings are 4 1-2 inches thick and 31 1-2 inches in diameter, and are fastened with nine taper bolts placed on a 25-inch pitch circle and varying from 2 5-8 to 3 3-4 inches in diameter. The thrust shaft, which has a diameter of 18 1-8 inches, is 14 feet 4 inches long and has nine 2 1-2-inch collars with a diameter of 27 5-8 inches. The thrust bearings are of cast iron lined with white metal, each shoe having water circulation, besides which the collars run in oil.

Each of the two three-bladed propellers is a true screw with detachable blades, and has a diameter of 20 feet, a mean pitch of 22 feet 6 inches, a developed surface of 98.7 square feet, and a

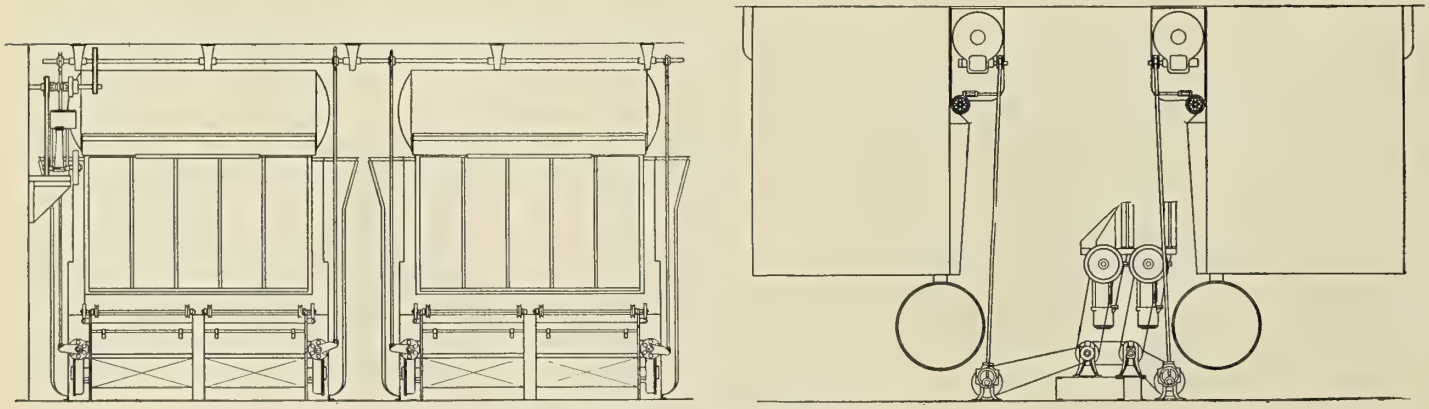


SWITCHBOARD IN CENTRAL STATION.
THE WESTINGHOUSE GENERATORS.

THE WESTINGHOUSE GENERATORS.
THE REFRIGERATING ENGINE ROOM.

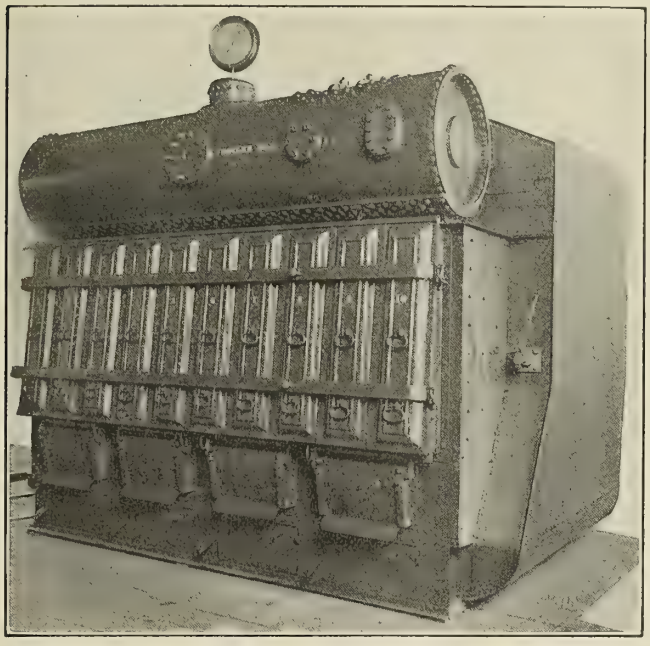
projected surface of 81.6 square feet. The blades are fastened to the hubs by nine steel studs each, with oval holes allowing a range of pitch adjustment from 21 feet 6 inches to 23 feet 6 inches.

Steam is furnished by a battery of sixteen Niclausse water-tube boilers placed in groups of four in each of four fire rooms. One of these groups has been fitted experimentally with Duluth automatic stokers, manufactured by the Whiting Foundry Equipment Company, of Harvey, Ill. These stokers consist of an endless belt of grate bars carried by two endless chains, one operating on each side of the furnace. The rate of progress of these grate bars through the furnace is given as 7 1-2 inches per minute. The back end of the stoker is adjustable vertically, so that the space between the grate bars and a cross water box above them may be regulated to suit the various sizes of clinkers resulting from the combustion of various kinds of coal. The water box prevents the unconsumed coal on top of the fire from being dropped into the ash pit, and also prevents the ingress of cold air between the grate bars and its own position. A small independent engine is installed to drive each of two sets of these stokers on opposite sides of the engine room. The body of the stoker is composed almost entirely of structural steel, the driving gear being inclosed in an



THE GENERAL ARRANGEMENT OF THE STOKER PLANT.

oil-tight and dust-proof casing, and a regulating device fitted for stopping the stoker, or for permitting a number of changes in speed, as may be required.



ONE OF THE NICLAUSSE BOILERS.

The boilers on the *Dakota* were made by the Stirling Company, and are duplicates of those on the *Minnesota.* Six of them are provided each with fifteen elements, two with seventeen, four with eighteen, and four with nineteen elements. Each element is made up of a malleable-iron header and twenty-four 3 1-4-inch tubes. The total heating surface in the sixteen boilers is 40,600 square feet, the grate surface hand fired being 811 square feet and with stoker firing 305 square feet. This gives a total ratio of heating surface to grate area of 36.4 to 1. The steam drums are made of steel plate 15-16 inch thick.

In addition to the natural draft furnished by the stacks, induced draft is provided for, and air heaters are fitted above each boiler. The gases are drawn through these air heaters by the induced draft fans, the air passing through ducts at the side of the boiler to the ash pits. By this arrangement it is heated to a temperature above 300 degrees Fahrenheit.

The Great Naval Battle of the Sea of Japan.

Contrary to general expectation, Admiral Togo fought a pitched battle with the Russian fleet under Admiral Rojestvensky on the afternoon and evening of May 27, and the engagement was continued throughout almost the entire day following. This battle was fought in the Korean Strait, between the Tsu Islands and the main Japanese group, in territory of Togo's own choosing, and appears to have been characterized at the start by a considerable element of surprise for the Russians, who had not expected to meet the enemy in such force at that point. The result, as all the world knows, was almost a complete annihilation of the Russian fleet, only four unarmored cruisers and a couple of destroyers having escaped either destruction or capture.

The Russian fleet consisted, according to the best available information, of the eight battleships *Kniaz Suwaroff, Orel, Borodino,* and *Emperor Alexander III,* of 13,516 tons each, *Oslabya* of 12,674 tons, *Navarino* of 10,200 tons, *Emperor Nicholas I* of 8,440 tons, and *Sissoi Veliki* of 8,800 tons; the three coast defense ships *Aphraxine, Oushakoff,* and *Senjavin,* of 4,126 tons each; the three old ironclads, now called armored cruisers, *Admiral Nachimoff* of 8,520 tons, and *Vladimir Monomach* and *Dimitri Donskoi* of 5,800 tons each; the six protected cruisers *Aurora* and *Oleg* of 6,650 tons each, *Svietlana* of 3,828 tons, and *Jemtchug, Almaz,* and *Izumrud* of 3,100 tons each. This makes a total of twenty war vessels, with a displacement of 153,104 tons. In addition to this force there are stated to have been in the Russian fleet thirteen torpedo destroyers, six auxiliary cruisers, five volunteer steamers, one tank steamer, the repair ship *Kamschatka,* and two hospital ships. The batteries carried by the twenty war vessels in this fleet included twenty-six 12-inch guns, seven 10-inch, four 9-inch, eight 8-inch, one hundred and twenty-six 6-inch, fifty-two 4.7-inch, and one hundred and thirty-four 3-inch guns.

Of this fleet, all of the battleships were sunk except the *Orel* and the *Emperor Nicholas I,* which were captured. The coast defender *Oushakoff* was sunk and the other two captured. All three of the armored cruisers were sunk. The *Jemtchug* and *Svietlana* were sunk, the *Almaz* and one torpedo destroyer escaped to Vladivostok, while the other three protected cruisers reached Manila, and have there been interned. A number of the special service ships have reached Shanghai or other Chinese ports, and will probably be held in those ports until the end of the war.

The Japanese fleet, which wrought this tremendous destruction, consisted of the four first-class battleships *Asahi, Mikasa, Shikishima,* and *Fuji Yama;* the second-class battleship *Chin Yen,* captured from the Chinese in 1894; the eight armored cruisers *Asama, Adzuma, Idzumo, Iwate, Kasuga, Nisshin, Tokiwa,* and *Yakumo;* besides a considerable number of protected cruisers, comprising nearly all of that type of ship in the Japanese navy. If the entire sixteen protected cruisers which the Japanese had in service were engaged in this battle, the fleet numbered thirty, with a total displacement of 198,470 tons. The combined batteries contained in this case three 12.6-inch, twenty 12-inch, one 10-inch, thirty-six 8-inch, two hundred and two 6-inch, one hundred and seventeen 4.7-inch, four 3.5-inch, and one hundred and seventy-two 3-inch guns.

There is no thoroughly satisfactory method of comparing these two fleets, even when we leave out of account the entirely elusive element of the personnel. A writer in *L'Illustration* has made a tentative comparison, basing his results upon a combination of displacement, horsepower, artillery, armor, and another item which is sub-divided between crew and proximity to naval base. To each of these five items he gives a maximum credit of 20 points, and figures that the Japanese possess this maximum in every case except horsepower, where they are given a grade of 18. This gives them a total of 98 points. In the Russian fleet full credit is given to horsepower, a mark of 18 to both displacement and armor, 18 1-2 to artillery, and 14 1-2 to the last item, making a total of 89. This ratio of 98 to 89 is thus given as the relative paper efficiency of the two fleets.

With the very uncertain element always entering into a proposition of this sort by reason of the presence or absence of torpedo craft, both surface and submerged, any method of getting at results from a mere comparison like the above is necessarily futile, the more so when we consider the fact that from published results to date a considerable number of the Russian ships met their fates by being blown up by submerged mines, or in some other manner entirely independent from the usual operation of ship against ship. If it had been a question of gun power only, which such a pitched battle usually implies, the advantage would have been somewhat with the Japanese by reason of the great preponderance of guns of 6-inch and 8-inch caliber possessed by their ships, notably by the splendid fleet of armored cruisers which they had in the battle.

Evaluating this on a purely arbitrary basis, allowing certain values per gun for all guns above 3 inches in caliber, the total value of those carried by the ships engaged was computed, and this result then affected by a coefficient indicative of the speed of the ship on which these guns were carried, the protection afforded the guns, and the age of the ship. By following out these processes the Russian guns figured out at 1,429 as compared with 1,726 for the Japanese, which figures may be taken as fairly representative of the relative artillery power on paper of the two

squadrons. They do not, however, take account of the splendid marksmanship shown by the Japanese and the wretched gunnery of their opponents, which appears to have been merely another case of Manila Bay and Santiago.

By the addition to their fleet of the four captured ships, the *Variag* from Chemulpo, and possibly one or two from Port Arthur, the Japanese will end the war with a navy equal to that with which hostilities were begun, while that of their opponent has been almost entirely destroyed. There still remain to Russia several battleships locked up in the Black Sea, three large ones building on the Baltic, half a dozen cruisers and small battleships in European waters, three or four cruisers at Vladivostok, and the various ships interned at points ranging from Chefoo to Manila.

supplied with steam from twenty Niclausse boilers installed in three separate boiler rooms.

The launch of this powerful battleship is of great interest when it is considered that she has penetrating powers at 3,000 yards which no armor on any ship afloat could hope to withstand. The armament consists of four 12-inch and four 10-inch rifles of great power, twelve 6-inch rapid-fire guns, twelve 12-pounder and three 3-pounder rapid-fire guns, as well as six Maxim guns, and five 18-inch submerged torpedo tubes.

The armor of the *Kashima* includes a belt from 9 inches to 4 inches in thickness, and a citadel of 6 inches, together with a 9-inch conning tower and 5-inch observation tower. The upper deck screen armor is 4 inches in thickness, and the 12-inch gun

THE LAUNCH OF KASHIMA, SHOWING BITS OF PAPER FLOATING AWAY FROM STARBOARD BOW.

The New Japanese Battleship Kashima.

The accompanying illustration shows the launching of the Japanese battleship *Kashima,* at the Elswick yard of Sir W. G. Armstrong, Whitworth and Company, Limited, which occurred on March 22, 1905. This battleship has a length of 425 feet and a breadth of 78 feet, the depth being 43 feet 6 inches and draft 26 feet 7.5 inches. The displacement is 16,400 tons. She is equipped with engines of 15,600 indicated horsepower, and is designed to operate at a speed of 18.5 knots. The normal coal supply is 750 tons, while the bunker capacity is 2,150 tons. The main propelling machinery consists of twin-screw, four-cylinder, triple-expansion engines, with cylinders measuring 36, 56, 63, and 63 inches in diameter respectively, and a stroke of 48 inches. They were constructed by Humphreys, Tennant & Company, of London, and are

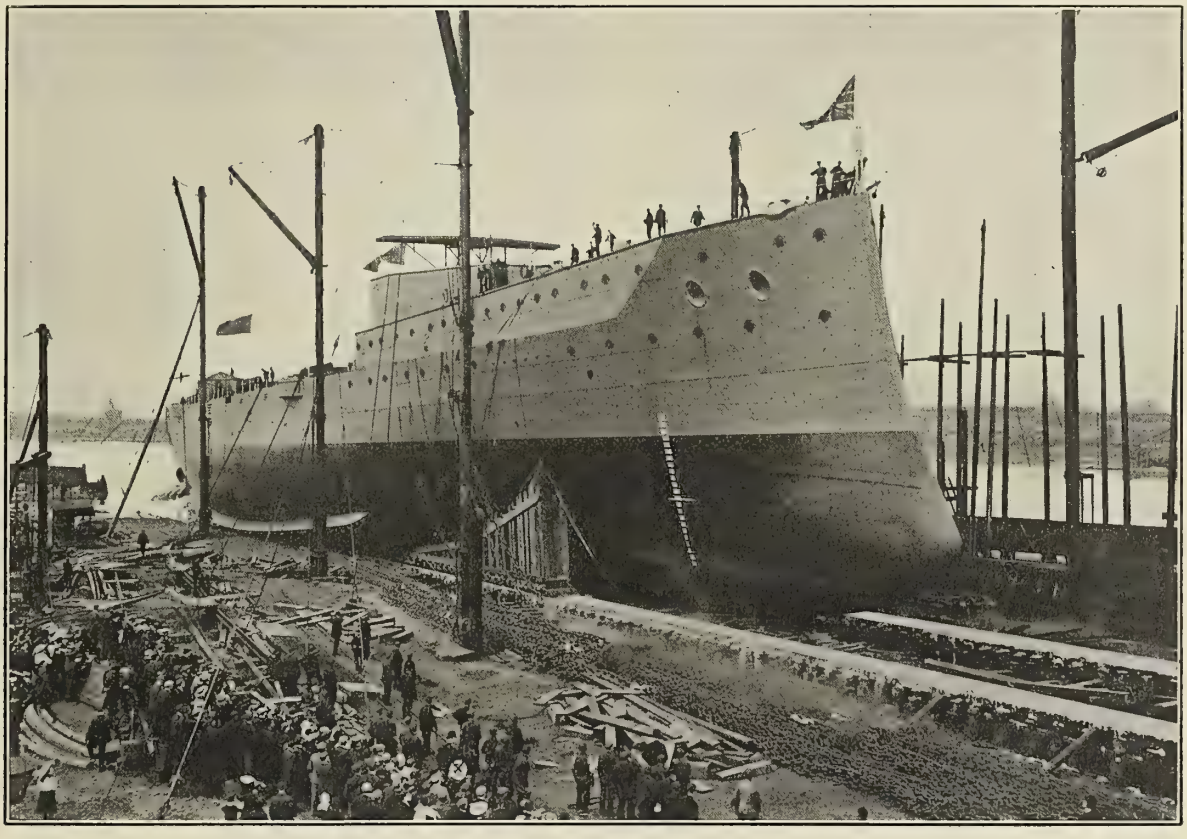
barbettes are 9 inches and 5 inches, while the 10-inch gun barbettes are 6 inches and 2 inches, making a most complete and almost impregnable protection.

The *Kashima* is the best battleship in the Japanese navy, holding a position in advance of any of the others as regards armament, hull and engines. Her speed of 18.5 knots per hour is in harmony with all other Japanese ships of the same type. To give some idea of the enormous aggregate power of the guns to be employed on the *Kashima,* it may be of interest to note that they were designed to be able to throw an effective weight of some eleven tons of steel per minute.

Kashima, the name given to this battleship by the Emperor of Japan, was that of one of his heroic ancestors whose shrine is situated in the province of Kashima, some fifty miles from Tokio.

It is also the name of one of the gods of war, the "Brother God Katori," whose temple is also situated in Kashima, but whose real history, dating back some 3,000 years before the first emperor, is not well known.

The Elswick shipyard, where the launching took place, is one of the greatest in England, some of the largest battleships having been constructed there during the past two decades. Their records show that since 1884 they have been responsible for the production of no less than 73 war vessels, representing almost every type, and constructed for fifteen different navies of the world. The displacement reaches a total of about 296,000 tons, and the aggregate horsepower of the machinery with which they have been provided is 672,000. Of these 73 warships 14 have been constructed for Japan and 21 for England; but the total tonnage of the British vessels amounts to just over 86,000 tons, while that for the Japanese navy is 105,000 tons, or 34 percent of the total of 296,000 tons. In the Japanese fleet at the commencement of the war were all these vessels, including the 17-year old cruiser *Idzumi*, originally the Chilian cruiser *Esmeralda*, and the fast protected cruiser *Yoshino*, which had previously taken part in the war with China, and was one of the ships lost during the operations before Port Arthur.



THE LAUNCH OF THE COCHRANE.

The Armored Cruiser Cochrane.

One of the finest armored cruisers afloat was put into the water May 20, 1905, by the Fairfield Shipbuilding and Engineering Company, Limited, of Govan, Scotland. This ship, which is one of the class first designed by Mr. Philip Watts when he succeeded Sir William White as Director of Naval Construction for the British navy, has a length of 480 feet, a beam of 73 feet 6 inches, and displaces at load draft 13,550 tons. The propelling machinery consists of two sets of triple-expansion engines having each four cylinders, and supplied with steam by nineteen Yarrow water-tube boilers and six single-ended cylindrical boilers, all made by the Fairfield Company. These are designed to work at a pressure of 210 pounds, and to give sufficient steam to allow the engines to develop 23,500 horsepower, with which it is expected that a speed of 23 knots will be obtained. The normal supply of coal is 1,000 tons.

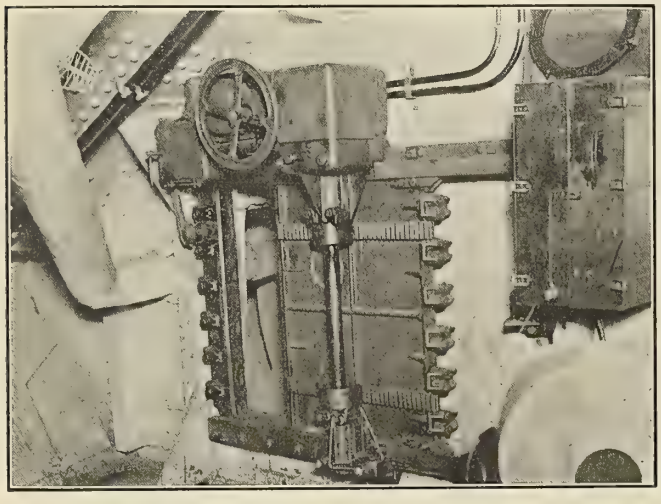
The armor protection of the *Cochrane* consists of a water-line belt 6 inches in thickness amidships, tapering to 2 inches forward and 4 inches aft. The protective deck, which extends from stem to stern, ranges in thickness from 3-4 inch to 2 inches; while a second deck of 1-inch armor forms a crown for the side armor and armor bulkheads. The battery, which is an unusually heavy one for a ship of the cruiser class, contains six 9.2-inch and four 7.5-inch rifles operating on the rapid-fire principle, while the secondary battery consists of twenty-eight 3-pounder rapid-fire guns and two 12-pounder boat guns, as well as two Maxim guns and three submerged 18-inch torpedo tubes.

The beautiful lines of this ship are shown in the accompanying photograph of the launch, the splendidly clear-cut bow in particular being noticeable. It is expected that these ships will prove the most efficient vessels of their class afloat, not only in speed and general seaworthiness, both of which are largely aided by the high forecastle, but also in maneuvring qualities and in battery power. It will be noticed that none of the main battery guns has a smaller caliber than 7.5 inches, and the broadside, which consists of four 9.2-inch guns and two of 7.5-inch caliber, is superior in striking power at long range to anything which could be brought to bear against it by any other cruiser of the same general type. This is readily seen by reference to the broadside of the American cruisers of the *Maryland* class, which consists of four 8-inch and seven 6-inch guns, and which at a range of more than two miles might be said to consist of four 8-inch guns only, so far as any attack on armor of more than four or five inches in thickness is concerned. We are indebted for the photograph to Mr. Allan McPherson, Jr., of Glasgow.

BULKHEAD CONSTRUCTION ON WARSHIPS.

Several things have given current prominence to the subject of bulkhead construction in warships: the report that the British Admiralty contemplated the abolition of watertight bulkheads; the lessons of the naval engagements in the Far Eastern war; and some important changes in the interior design of warships.

As to the report that British naval authorities are considering the abolition of watertight bulkheads, it may be said on good authority that there is not the slightest foundation for the various rumors to this effect which have gained currency in the past few months. It appears that those who have been responsible for the reports referred to, are not only entirely misinformed as to the Admiralty's intentions, but have too slight a knowledge of the subject to realize the absurdity of the statements they have put forth. The English naval expert, Mr. Herbert Russell, disposes of these statements with the remark that "To credit the Admiralty with the intention of abolishing the one great safe-guarding condition of stability at a time when its value was never so great, owing to the development of the modern methods of warfare, would be simply ludicrous were it not that a certain element of mischief lurks in such irresponsible tales."



HORIZONTAL BULKHEAD DOOR ON U. S. S. COLORADO.

So far as can be discovered the sole basis for these tales is that the construction department of the British navy has had under consideration for some time past, certain modifications in bulkhead design. But these modifications refer principally to armored doors, which have long been recognized as the greatest source of weakness in the interior walls of steel with which the modern warship is fitted. The number of doors is to be reduced to as few as shall be consistent with ready communication between the different parts of the ship, and a new pattern of door is to be introduced, consisting of either vertical or horizontal sliding armor plate, opened and closed by mechanical means. While these statements are made on good authority, they can be offered only as representing the intentions of the British Admiralty so far as they have been fixed at the present time, and these intentions are, of course, subject to modification. It is true that the old pneumatic and hydraulic systems of power doors did not give satisfaction, and their admitted faults and deficiencies are perhaps responsible for the prejudice which lingers in the minds of some British naval authorities against the power door. Here, the development of bulkhead power doors has called electricity to aid in the solution of the problem, while the hydraulic-pneumatic system installed on some foreign ships is substantially the same as that abandoned by American designers in favor of electricity.

THE "LONG-ARM" SYSTEM.

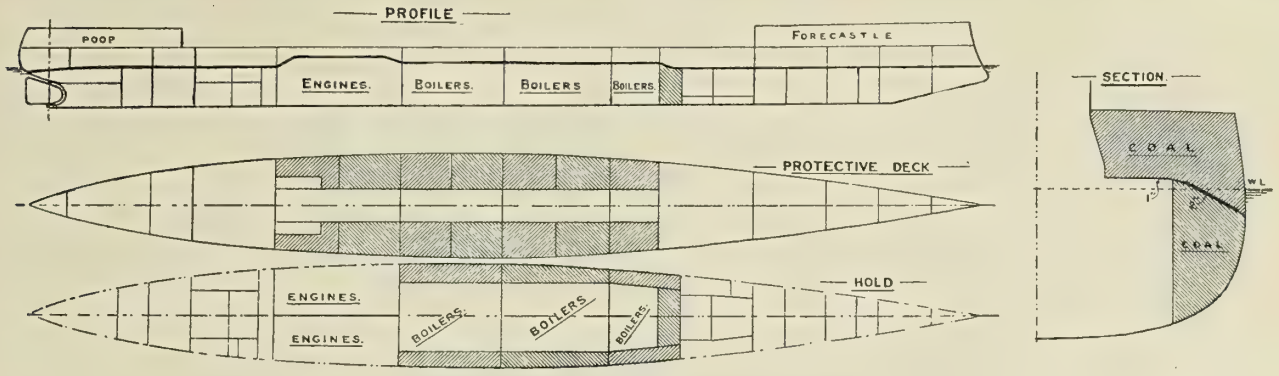
Recognizing the supreme importance of the bulkhead-door problem, British naval authorities have watched with a great deal of interest the progress of the installation on United States warships of the "Long-Arm" system of power doors and hatches. English naval and technical journals have paid a great deal of attention to the design and operation of this system, and several of these organs are urging the desirability of adopting the same system for the warships of the British navy. Without going into the details of the system, it may be said that it consists of power doors and hatch plates each provided with electrical motors and connected by electrical conductors with a central emergency station located above decks. It is possible to close all the doors and hatchways so connected by starting the mechanism of the emergency station. Hand-levers on both sides of the door secure local control when the emergency is on, and a limit switch gives security against the blowing out of fuses in the event of the doors encountering an obstacle as they come to a close. The emergency station is provided with an indicator which shows at once whether or not all the doors or hatchways under control have shut, and a diagram numbered to correspond with the numbers of the doors enables the officer in charge to ascertain immediately the location of any trouble. This system is now installed on eighteen ships, and thirteen more are to have the same equipment.

VERTICAL BULKHEAD DOOR ON U. S. S. COLORADO.

The door can be operated by hand lever while emergency is "on."

LESSONS OF THE FAR EASTERN WAR.

As to the lessons of the Far Eastern war, these are somewhat different from the public impression in regard to them, so far as bulkhead construction is concerned. Several times Russian ships were torpedoed by the Japanese, and many of these ships sank after greater or less intervals of time. In most cases, however, the damaged ship did not sink—she merely settled—thus giving direct testimony to the value of the watertight bulkhead. Without these bulkheads every Russian ship which encountered a Japanese mine or was torpedoed, would have gone to the bottom at once. As a matter of fact, nearly all the ships under which mines and torpedoes were exploded managed to escape, even though seriously damaged.

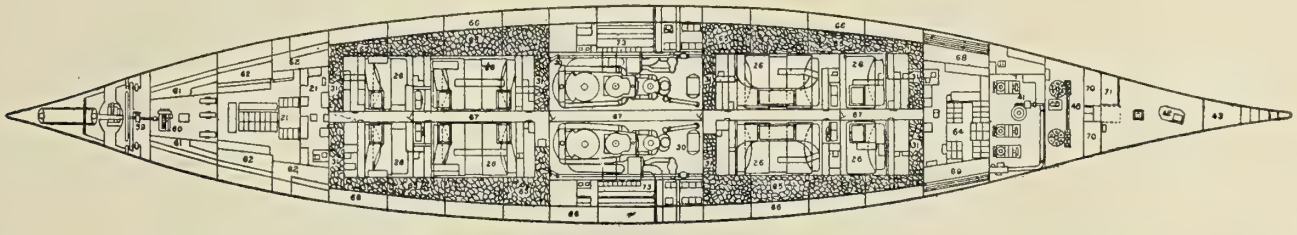


WATERTIGHT SUBDIVISIONS OF A THIRD-CLASS CRUISER.

(From Attwood's "Warships.")

The lessons, then, of the naval warfare in the Far East cast discredit neither upon the torpedo nor the watertight bulkhead. They confirm the long-standing belief of naval engineers that if it were practical to divide a war vessel into a sufficient number of watertight compartments, the torpedo would, indeed, be rendered impotent; but for various reasons it is impossible to multiply the number of bulkheads. One of these reasons is involved in the question of weight.

If, however, the unsinkable ship is unattainable because the present means to that end, if extended, would impair stability, cross the ship—vary in number. The diagrams herewith show their number and arrangement in a first- and third-class cruiser. The bulkhead nearest the bow and extending to the upper deck, is the collision bulkhead, and has probably saved more ships than all the other bulkheads put together. According to the latest practice, no openings of any kind are allowed in this bulkhead. In some cases an additional bulkhead is erected from three to five feet abaft the collision bulkhead, with a view to preventing the inflow of water in case the collision bulkhead should be damaged. The transverse bulkheads between the engine and boiler rooms are



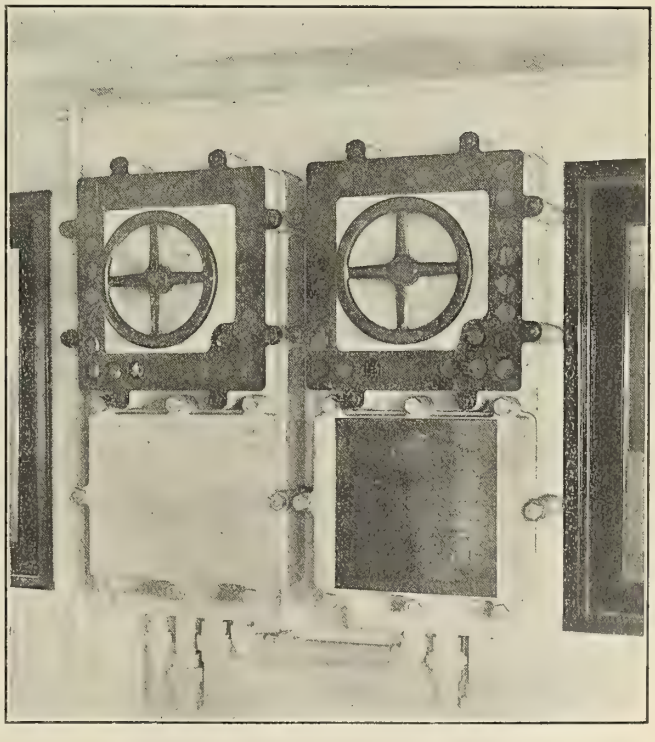
SUPERIOR HOLD OF JAPANESE CRUISER KASUGA.

it does not follow that no further progress in this direction is to be looked for. Changes in warship design, all in the way of progress, are constantly going on—so constantly indeed that it is difficult to keep pace with them. The latest news is that the Board of Naval Construction intends to make important changes in some of the ships now building. Heretofore the construction of a ship after the general board recommended its tonnage, battery, and speed, and the Board of Construction passed the plans, has been entirely under the direction of the Bureau of Construction and Repair and the shipbuilders to whom the contract was awarded. Officers of the line, upon whom devolves the duty of commanding the ship, have had, from the time the craft was laid down until it was commissioned, little to do with its construction. But now the period of change is to be extended to cover almost the whole life of a warship on the ways, and the men who fight our warships are to have more to say about their design and equipment.

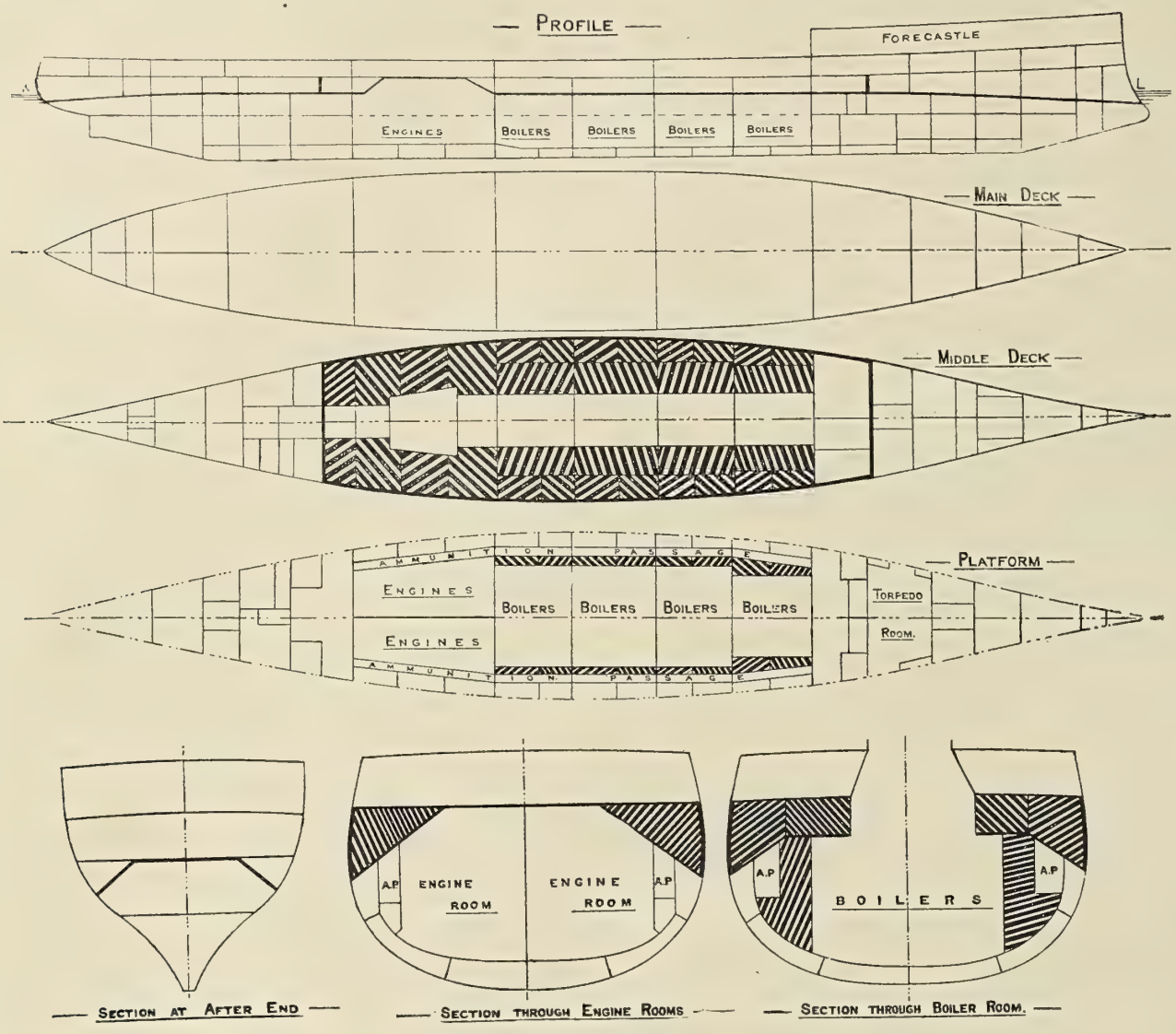
FUNDAMENTALS OF BULKHEAD CONSTRUCTION.

It is possible, notwithstanding these incessant changes, to state in outline the fundamentals of bulkhead construction and the main methods of the watertight sub-division of a ship. The latter are: (1) A watertight inner bottom. (2) A watertight deck. (3) Transverse bulkheads. (4) Longitudinal bulkheads. In smaller vessels the double bottom is often dispensed with on account of the space it occupies.

The transverse bulkheads—watertight partitions extending ac-



EMERGENCY STATION OF "LONG-ARM" SYSTEM.



WATERTIGHT SUBDIVISIONS OF A FIRST-CLASS CRUISER.

(From Attwood's "Warships.")

usually specially constructed, both on account of their importance and because of the additional stiffening required for a large area and depth of unsupported plating. The governing feature in the construction of all bulkheads is the area of unsupported plating likely to be exposed to water pressure.

Bulkheads forming the fore end of the forward boiler room and the after end of the engine room do not require the extensive stiffening applied to the divisions between the engine and boiler rooms, because the former receive support from decks and platforms. In between the main transverse bulkheads, divisional bulkheads are placed in the upper and lower side bunkers, and beneath the watertight flat in the upper bunkers of battleships an additional set of bulkheads is fitted, thus providing for the most minute sub-division of the ship in the region of the water-line. It will be noticed in the diagrams that a number of the bulkheads are carried up to the upper deck in view of the possibility of change of trim that might follow puncture of the hull.

LONGITUDINAL PARTITIONS.

A number of longitudinal bulkheads form the boundaries of magazines and other compartments, and thus assist in maintaining the watertight sub-division. Their small area makes massive construction unnecessary. Only the four principal fore-and-aft bulkheads need be described. These are: (a) The middle line engine-room bulkhead. (b) The inner coal-bunker bulkhead. (c) The outer coal-bunker bulkhead, and (d) the upper coal-bunker bulkhead. All of these are plainly shown in the diagram of the bulkhead system of a first-class cruiser. In smaller ships the two bulkheads last mentioned are sometimes omitted in order to increase the coal-carrying capacity and to make handling of coal easier.

The engine-room bulkhead extends the whole length of the engine room, and is carried up to the main deck. On account of the strain which would come upon it in case one engine room was flooded, this bulkhead is constructed as carefully and heavily as the main transverse bulkheads.

The inner coal-bunker bulkhead is supported by the divisional bulkheads in the bunkers, and the outer coal-bunker bulkhead is virtually a continuation of the inner bottom. It is usual to distinguish the transverse bulkheads by the number of the frame at which they stand. Longitudinal bulkheads are numbered to correspond to the frames at which each begins and ends. Bulkhead 100 to 120 would thus be the one extending between the frames bearing the same numbers.

THE CENTRAL TUNNEL.

In connection with this subject there are points of interest in the new Italian-built Japanese armored cruisers *Kasuga* and *Nisshin*. The central position of the engines, with the corresponding disposition of armament, dictated to a great extent the structural

arrangement of the ships, which is, however, on the whole, the same as is usual in ships of their size and class, with the exception of a central tunnel running along the middle line of the ship close underneath the armor deck, and between and above boilers and engines. The idea of such a tunnel was taken from English warships, which had a similar central passage. But while in the British ships the side bulkheads of the tunnel went down to the inner bottom and formed magazines below, the Japanese ships, failing the necessary space below, are contented with the tunnel above, which, as in the English ships, was intended as a thoroughfare for easy communication between the various machinery compartments, for easy and accessible passage of electric wires, speaking-tubes, telegraphs, for the maneuvring of the main drainage valves, etc., and for eventual conveyance of ammunition from end to end, should necessity occur. This last utilization was, however, subsequently discarded, the tunnel being shut at the ends, with no communication with the ammunition compartments. The tunnel is supported in the engine rooms by the central longitudinal bulkhead which separates the two engines, and by pillars in the boiler rooms, in two rows along the central longitudinal passage between the boilers.

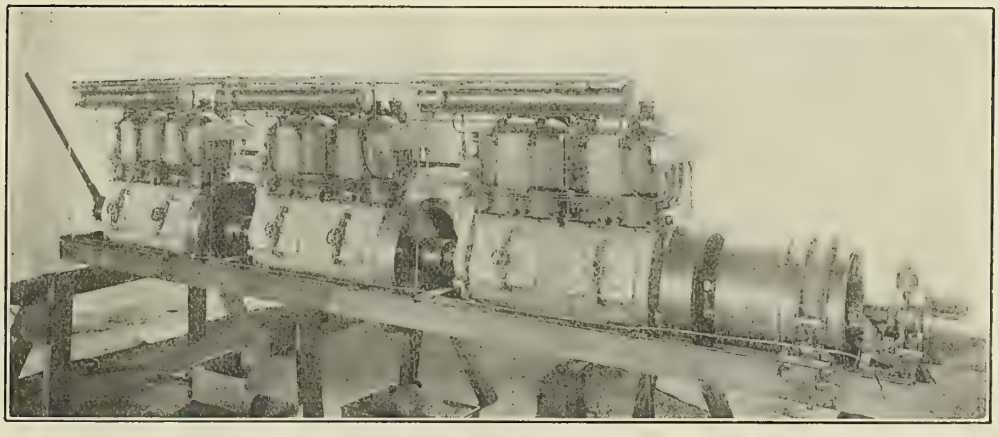
In addition to the usual cofferdams around the hatchways of the protective deck, a cofferdam about 30 inches wide was built at the side of the Japanese ships from the protective deck to the main deck, to allow leakages to be stopped at the sides and the slopes of the armor deck to be cleared of water should damage occur to the armor belt.

We have to record the death, on May 17, of Mr. Edwin McCalla Davis, secretary of the Niles-Bement-Pond Company.

A New Auto Boat.

With hull designed by B. B. Crowninshield, and built by Stearns & McKay, at Marblehead, Mass., a remarkable automobile boat has just been completed by the Winton Motor Carriage Company, of Cleveland, O., which is expected to develop a speed of thirty miles per hour. The length is 40 feet over all, the beam at the water-line 4 feet 3 inches, and the extreme beam 4 feet 8 inches. As shown in the illustration, there is a long turtle back forward, and considerable freeboard, the stern being wide and of relatively low freeboard; but the ship is not of the extreme wedge pattern which has characterized some of the recent racers in European waters. The length of the turtle back is about 25 feet, and the motors will be placed under the after part of it. The frame is extremely rigid for the weight of material used, and no attempt has been made to sacrifice everything for the sake of lightness. The frames are of oak, 5-8-inch square, with fore-and-aft stringers 1 3-4 inches square. The planking is 1-4-inch Spanish cedar, and is so arranged that each seam is backed by one of the stringers, this making a watertight hull without the necessity of calking. The boat weighs 1,200 pounds, and the displacement is about 4,000 pounds.

THE HULL OF THE WINTON RACER.



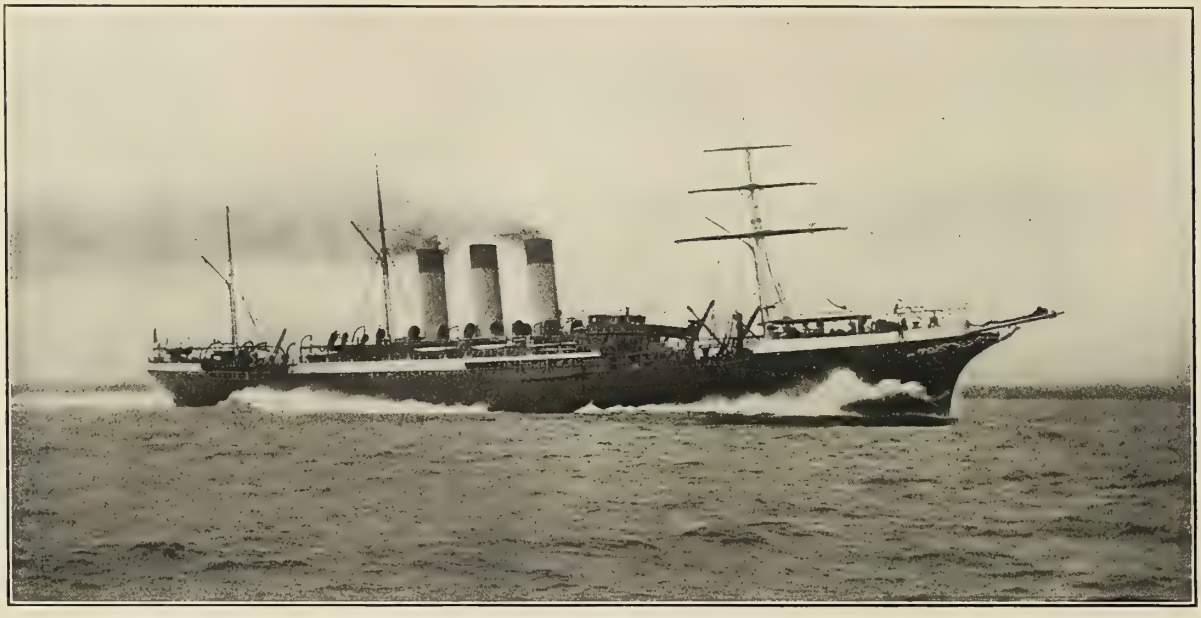
THE TWELVE-CYLINDER ENGINE.

The most remarkable feature of the craft, however, is the 12-cylinder engine, which is designed to develop anywhere from 120 to 150 horsepower. It is composed of three 4-cylinder engines of 40 to 50 horsepower, each of the exact size and character used in model A touring car, the bore of the cylinder being 5 1-4 inches and the stroke 6 inches. The engine is water cooled, the cylinders being cast in pairs with water jackets and exhaust-valve chambers in the same casting. Hand-hole covers on the crank case give immediate access to crank shaft, connecting rods, and pistons.

RUSSIAN VOLUNTEER FLEET STEAMERS.

BY FRANK C. PERKINS.

A number of the Russian volunteer fleet steamers have been constructed in English shipyards, and it may be of interest to note some of the details of construction of the two vessels *Kherson* and *Smolensk*, recently completed at the Hebburn shipbuilding yard of R & W. Hawthorn, Leslie & Company, Limited, of Hebburn-on-Tyne.



KHERSON.

SMOLENSK.

The Russian volunteer fleet steamer *Kherson* is of the twin-screw type, having a length over all of 493 feet. The molded depth of this steamer is 37 feet 3 inches, while the breadth is 54 feet 3 inches. She is fitted with accommodations for 1,480 troops and 72 officers or first-class passengers, and 46 third-class passengers. Provision is made for the mounting of seven 4.7-inch guns. The main engines consist of two sets of the triple-expansion type, having a stroke of 54 inches. The high-pressure cylinder measures 36 inches in diameter, the low-pressure cylinder 92 inches, and the intermediate 57 inches. The steam is supplied from 24 Belleville boilers working at a pressure of 250 pounds per square inch. This fleet steamer has attained, on trial, a speed of 19.5 knots.

The twin-screw transport steamer *Smolensk* was originally designed for trade between Russia and the far east, in time of peace carrying cargo and immigrants, and in time of war being used as a fast cruiser. The total length of the *Smolensk* is 506 feet over all, the depth being 37 feet, and the breadth 58 feet. This vessel is fitted up with cabin accommodations for 1,560 troops and 86 officers, and provision is made on her decks for 18 quick-firing guns and for 10 ammunition magazines on the orlop-deck with steel trunkway leading thereto from the upper deck. She is fitted with electric-fan ventilation throughout; also large steam bread oven, disinfecting plant, and cold-storage rooms, as well as steam laundry, four galleys, and two hospitals. Her water-tight bulk-

heads are so spaced and strengthened that any two compartments may be in open communication with the sea without the vessel's foundering. The steam suction pipes in the holds are also said to be of a most efficient kind, the pumps being capable of delivering over the side 800 tons of water per hour.

The main engines of the *Smolensk* consist of two sets of the marine triple-expansion type, each having six cylinders, with a stroke 48 inches in length. The two high-pressure cylinders are 26 inches in diameter, the two low-pressure cylinders 75 inches in diameter, and the two intermediate cylinders are 44 inches in diameter. They are so arranged that one high, one intermediate, and one low pressure on each shaft can be thrown out of action when cruising at half power. The engines of this Russian volunteer fleet steamer are supplied with steam from 24 Belleville water-tube boilers working at a pressure of 250 pounds per square inch. On trial this vessel has attained a maximum speed of 20.25 knots, and is said to have given excellent service. She escaped into Woosung, the port of Shanghai, after the disastrous naval battle of the Sea of Japan.

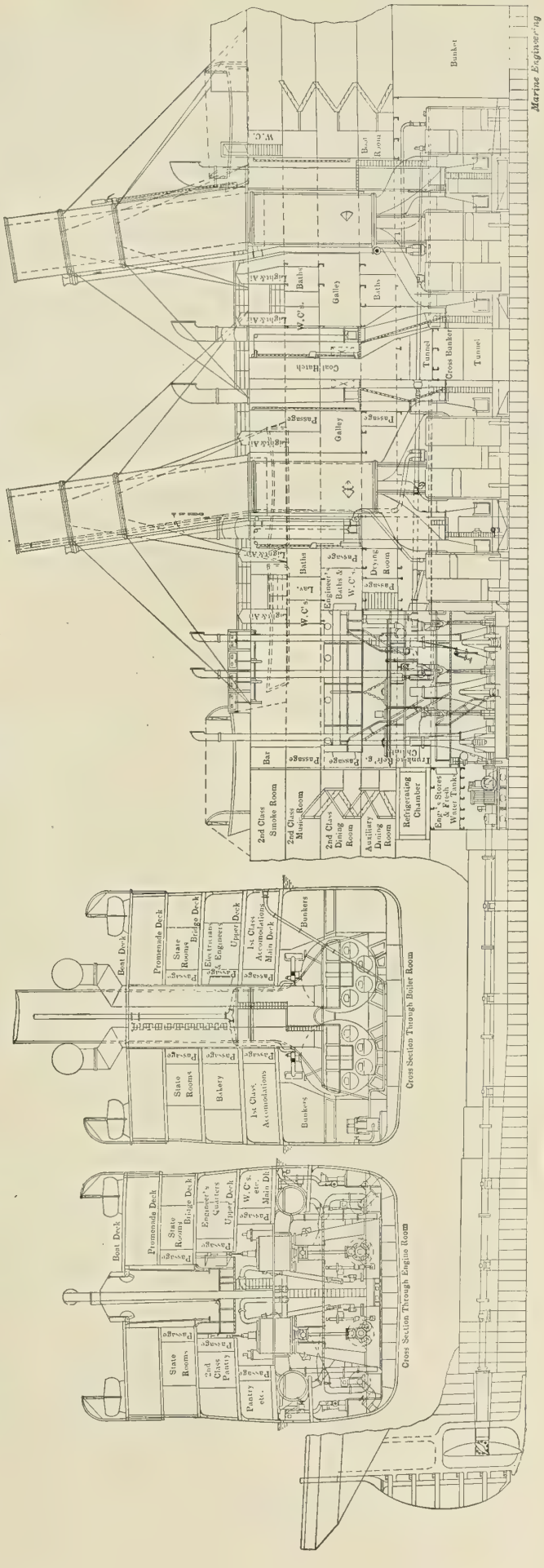
MACHINERY OF THE NEW ANCHOR LINER CALEDONIA.

BY BENJAMIN TAYLOR.

The *Caledonia,* built by D. & W. Henderson Company, of Glasgow, is 515 feet long, 58 feet broad, and 36 1-2 feet deep, and has accommodation for 300 first-class passengers, 400 second-class, and 800 third-class or steerage. Her draft of 27 feet has been limited to enable her to navigate the river Clyde up to Glasgow. The gross tonnage is 9,400, and load displacement 16,000 tons. She is driven by two sets of triple-expansion engines, each set having three cylinders measuring 31 1-2, 51 1-2, and 85 inches in diameter respectively, with a piston stroke of 54 inches.

The cylinders of each engine are rigidly bolted together and stand on six massive cast-iron columns, the front or inner columns being of rectangular section and divided at the bottom for the double purpose of giving fore-and-aft rigidity to the engines, and also, by permitting the cranks to pass between the columns' feet, of providing ample room on the starting platform between the two engines. The back columns are of cylindrical section, with sufficient taper in their length to provide ample area at their bases to ensure stiffness. The sole-plates, to which the columns are securely bolted, are made in three pieces bolted together. They are of hollow rectangular section, and have strong flanges at the bottom for fixing the engines to the top of the ballast tank. The crank-shaft is in three interchangeable parts and is of the built-up type. Each part is carried on two bearings of extra length, lined with white metal. The bearings throughout the entire engines are made with extra large surfaces, so as to ensure efficient working and minimize the possibility of accident.

The cross-head guide plates on the columns are of hollow section, through which an ample cold-water circulation is provided. The air pumps are on Edward's patent system, and are fixed to the back columns of the intermediate engines, from the cross-heads of which the pumps are driven by means of the usual levers; attached to the air pumps, one on either side, and driven by the same cross-head, are two bilge pumps. The condensers are carried on the lower deck beams close to the side of the ship, and quite separate from the main engine structure; the cold-water circulation through them is supplied by two large centrifugal pumps driven by vertical steam engines, and placed on the level of the starting platform between the low-pressure engines and the ship's side, the diameter of the delivery pipe being 16 inches. There are no feed pumps driven direct by the main engines, the whole of the water necessary for feeding the boilers being supplied by two pairs of Weir's feed pumps of large capacity, each pair being sufficient to provide the entire feed water required. There is to each set of pumps a pipe leading from the hot well to a float tank, with automatic control valve. One pump taking the water from this float tank first passes it through an Alley &



SECTIONS THROUGH ENGINE AND BOILER ROOMS, AND INBOARD PROFILE OF ANCHOR LINE STEAMSHIP CALEDONIA.

McLellan Sentinel feed filter, and then into one of Weir's patent direct-contact feed heaters, from which the other pump draws the heated water and delivers it through the main line of feed pumps to the boilers.

To ensure the rapid manipulation of the main engines in narrow waters, a direct-acting steam reversing engine is provided, the cylinder of which is attached to the back of the main cylinders, and controlled by levers from the starting platform. The gear for regulating the main stop valves is placed close to the reversing levers, and is of a dual nature. To permit of the accurate adjustment of the valves a screw gear worked by a hand wheel is provided, but in case of emergency the steam supply can be instantly shut off the engines by simply pulling a lever. At the after end of the engine room is the thrust recess, which extends from side to side of the vessel; in it the thrust blocks are secured to steel seats built upon the ballast-tank top. The thrust of each propeller is taken up by collars on the thrust-shaft bearing upon ten horse-shoe rings having large white metal bearing surface provided with water circulation. The tunnel shafting is made up in five convenient lengths, each carried on a pillow block, with white metal lining and water circulation in each. The propeller shaft is carried inside the skin of the ship right up to the stern frame and has on this account to be of extra length. To avoid corrosion where it is exposed to the salt water it is covered by a gun-metal liner from the fore end of the stern tube to the propeller boss. The propeller bosses are of cast iron, to which are secured by studs and nuts the bronze blades, four each, the propellers being 17 feet 10 1-2 inches in diameter.

In the thrust recess are fitted four donkey engines and auxiliary condenser with drain tank; also a refrigerator on Hall's patent. The donkeys are for salt-water service, fresh-water service, bilges, and one for circulating through the auxiliary condenser.

The electrical machinery is placed on the lower deck level on the forward side of the main condensers, either set being capable of lighting the whole ship, as well as driving a large number of powerful electric fans which are provided for ventilating purposes. The dynamos are driven direct by vertical Belle's compound steam engines, the steam and exhaust pipes of which are independent of all other machinery.

The pumping arrangements are on a very complete scale, and comprise principally two extra large duplex ballast pumps, one on either side of the engine room. The ballast and bilge-pipe connections are in duplicate, a complete system being on either side of the vessel, with connecting pipes at the after end of engine room; the two pumps may work independently, or both may be connected to draw from any one compartment of the vessel. By this arrangement it will be seen that in the event of a considerable leak occurring in any part of the ship there is ample provision for overcoming it.

Steam is supplied by four large double-ended boilers and four single-ended boilers. These boilers are on the natural draft system, and are arranged in two sets with a funnel to each set. The funnels are 115 feet high, and have an outer casing throughout their entire length whereby the hot air accumulating over the boilers may be drawn off. There are in all 48 furnaces, giving a large heating and fire-grate area. The main steam pipes are led in duplicate, each engine having a separate pipe the whole length of the boiler space; a valve is fitted on the after side of the forward engine-room bulkhead connecting these pipes for the purpose of equalizing the steam pressure at the engines.

The placing of the boilers in pairs permits the use of side bunkers throughout the entire boiler space, these bunkers being of sufficient capacity to carry the vessel across the Atlantic, and it will be observed that by this arrangement the coal runs naturally to the place at which it is required, thereby practically doing away with the necessity of carrying coal trimmers. A cross bunker is placed between the two sets of boilers.

For dealing with the large cargo which the vessel is designed to carry, ten powerful steam winches of the builders' own special make are placed on deck, with cylinders of 7 inches in diameter and 12 inches stroke, and provided with winding barrels of extra large diameter, thereby giving extra speed in hoisting cargo.

In addition to the large fresh-water tanks and for cases of emergency a large distilling plant for condensing salt water is provided. The steam steering gear is fitted in a special house on the poop and is worked from the bridge by a controlling shaft. It is of the Caldwell & Company's make, and is of ample power. The hand steering gear is arranged in the same house, and also Cumming's patent oil-cylinder rudder-brake, supplied by the builders.

When on her trials on the Clyde, the *Caledonia* attained a speed of 18 1-4 knots loaded, which is considerably in excess of what was required, and though this speed was attained within six hours of the time the engines were first started, everything worked with the most satisfactory smoothness. The indicated horsepower was 11,750. The *Caledonia* left Glasgow for New York on her maiden voyage on March 25.

New Armored Cruisers.

BY EDWIN CERIO.

The keel of the armored cruiser *A* was laid in November last at the Royal Navy Yard of Castellamare, Italy, the two new cruisers *A* and *B*, as they are referred to in the 1904 estimates, having been designed by one of the most able naval architects of the Italian navy, General Masdea. They embody a fortunate compromise between the requirements to be met by ships of their class, and mark in many respects a new departure in the armament and protection of armored cruisers. Though about identical in size to the United States cruisers *Charleston, Milwaukee,* and *St. Louis,* the Italian vessels differ from these in their military qualities, as they possess to a very high degree the tactical virtues of cruising ships: protection, armament, and speed. Some information on the new Italian cruisers will surely be of interest, as an opportunity is offered of comparing, in ships of the same displacement and dimensions, a very different distribution of fighting elements.

The principal characteristics of the armored cruisers *A* and *B*, *Charleston* and class, and of the new French cruiser *Edgard Quinet,* are gathered in the table given herewith. The construction of the *Quinet* was begun in Brest, France, at the end of September, 1904, so that she may be assumed to represent the up-to-date French naval policy and practice in the construction of swift armored cruising vessels. The three types of ships chosen will enable a comparison between the military qualities of fighting units intended to solve the armored cruiser problem, each from a different viewpoint.

Much blame has been given the naval authorities responsible for the *Edgard Quinet's* design, and for that of her sister ship *C* (French Navy Estimates, 1905). The *Quinet* is a typical specimen of those ships which have so well deserved their name of "coal-eaters." To obtain one or two knots in addition to the high speeds already obtained by cruisers above 10,000 tons displacement means to overpower these vessels, a practice which has proved most uneconomical, and which has led to failures such as the *Jeanne d'Arc* and the ships of the *Gambetta* class.

With a moderate displacement and a speed quite sufficient for cruising purposes the Italian cruisers carry a formidable armament. Though the number of guns is inferior to that of the *Charleston* and the *Quinet,* the calibers chosen are almost equal to those of the heavy guns of a battleship. Considering the ranges of modern warfare, the armament of *A* and *B* seems more appropriate to armored cruisers than that of the new French and American vessels of this class.

High speeds in swift cruisers must be made, up to a certain degree, paramount to other fighting qualities, and a vessel of 14,000 tons displacement running at 24 knots is certainly an ideal armored cruiser. But the unromantic side of the question must also be considered. The estimated cost of the *Quinet* is $8,000,000; that of the Italian cruisers $4,400,000. Making an allowance for the

Principal Characteristics.	New Armored Cruisers.		
	Italian. A and B.	United States. Charleston.	French. Edgard Quinet.
Displacement ... .tons.	9,675	9,700	14,000
Length on the water-line..feet.	427	423	528.2
Extreme breadth..... "	68.8	65.5	70.5
Draft..... "	23.5	23.25	26.5
Block coefficient.....	0.487	0.543	0.492
Approximate area of lateral plane (torpedo target) sq. ft.	9,700	9,500	13,500
Speed (estimated).....knots.	22.5	22.	24.
I. H. P. (designed).....	18,000	21,000	40,000
Admiralty coefficient.....	287	231	201
Armor.....	Terni.	Krupp.	Krupp.
Belt, maximum thickness, ins.	7⅞	4	6
Battery, " " "	7⅛	4	6
Casemates " " "	....	4	....
Barbettes of primary guns, "	?	None.	6
" " secondary " "	?	None.	6
Conning tower..... "	7⅞	5	....
Armament:			
Primary.....	4 10-inch in double turrets, forward and aft, 8 8-inch in double turrets.	14 6-inch behind shields and in box batteries.	2 9.4-inch in single turrets, 14 6.4-inch in double turrets and casemates.
Secondary	16 3-inch.....	18 3-inch unprotected.	....
Tertiary.....	8 3 pounders..	12 3-pounders, 12 1-pounders, 2 gatlings 8 Colts.	8 6-pounders, 16 3-pounders, 2 1-pounders.
Torpedo tubes { above water.	Two, at sides.	....	Three.
Torpedo tubes { submerged..	One, astern.	Four.	Two.
Coal supply { normal....tons.	700	650	1,500
Coal supply { maximum, "	1,500	1,500	2,400

difference of wages in France and Italy, it may be roughly assumed that the cost of two *Quinet's* would cover that of three *A*-type cruisers. On the other hand, three *A*-vessels would mean, strategically and tactically, a force far superior to two *Quinets*. Within probable ranges—4,000 to 8,000 yards—the armor carried by *A* defies penetration from the guns of the *Quinet* and *Charleston,* while the *A's* 10-inch guns would pierce both the *Quinet's* and the *Charleston's* side armor.

The comparison made above is founded on data given in the table, most of which is taken from official sources; when more particulars are known of the Italian cruisers now in course of construction, it will be most instructive to see how the weights of the different elements have been distributed, in order to obtain such a happy compromise as that which the two vessels seem to embody.

PERSONAL.

Captain C. O. Tilton, of Martha's Vineyard, Mass., has just been appointed captain of the steamship *Massachusetts* of the Atlantic Transport Line.

Mr. Charles S. Davis, for the past six years master electrician of the Bureau of Construction and Repair, Charlestown navy yard, joined, on June 1, the engineering staff of the Holtzer-Cabot Electric Company, Boston, Mass.

The Warren Steam Pump Company, of Warren, Mass., has opened an office in New York at 95 Liberty street, and Mr. W. D. Kearfoot, who has been well-known for many years in connection with the pump business, has been made manager.

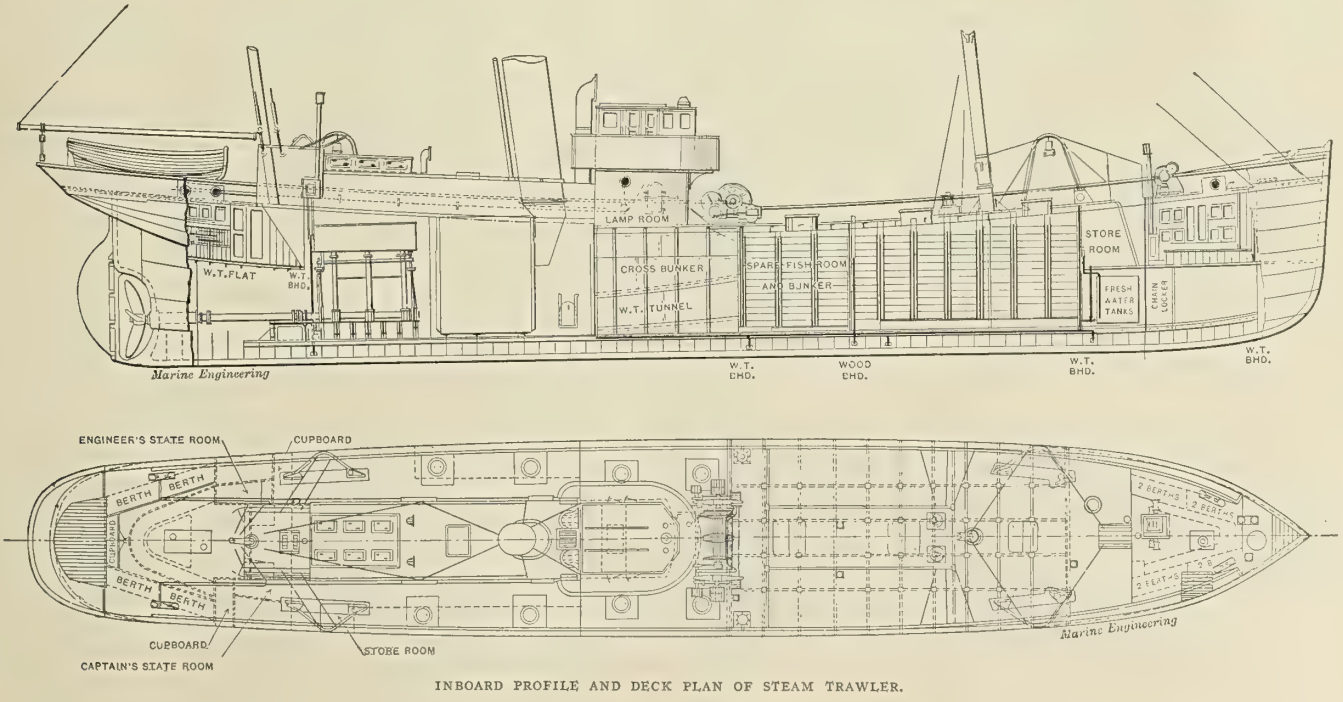
Mr. Eads Johnson has resigned his position as Superintendent of Construction of the United States Lighthouse Service, at Tompkinsville, N. Y., to become the Maritime Exchange representative for James Shewan & Sons, shipwrights and machinists.

The firm of Gardner & Cox, naval architects, has been dissolved, and Mr. William Gardner, retaining the old offices at 1 Broadway, will continue the business of a naval architect; while the Messrs. Cox have formed a new firm of naval architects and marine engineers, in copartnership with Col. E. A. Stevens and Mr. E. A. Stevens, Jr., under the firm name of Cox & Stevens, being located in the Morris Building, New York.

Developing the Canadian Merchant Marine.—Canada is taking steps to develop her merchant marine. The dominion parliament has just voted a liberal appropriation for the five schools of navigation at Montreal, St. John, Victoria, Halifax, and Yarmouth. A general preliminary training in seamanship is given to a large number of young men, many of whom ship with a good start in the knowledge required on merchant vessels.

The North Sea Steam Trawler.

In amplification of the article on the steam trawler, published at page 66, in Marine Engineering of February, 1905, we present herewith reproduction of a drawing of one of these trawlers, showing the general arrangement of the machinery and other compartments, and in particular giving an idea as to the location and extent of the storage capacity for fish, which occupies about one-third the length of the vessel. It will be seen that the entire design is very compact, the engine being placed very near the stern, thus minimizing the necessary length of shaft and the space required for its installation.



INBOARD PROFILE AND DECK PLAN OF STEAM TRAWLER.

Marine Engineering

Published Monthly by

MARINE ENGINEERING
INCORPORATED.

17 Battery Place, - - NEW YORK
12 St. Benet Place, Gracechurch St., LONDON, E. C.

H. L. ALDRICH, President and Treasurer

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE,
Vice-President and Advertising Representative

Branch Offices. Philadelphia, Pa., Machinery Dept., The Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents
Other countries in Postal Union	10/6	1/-

Entered at New York Post Office as second-class matter.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of the July issue of Marine Engineering comprises 5,500 *copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the* 5,500 *copies represent legitimate circulation.*

Motor Boats.

As announced last month, we are starting this month the publication of a series of articles on "Motor Boats," by Professor Durand, the scope of which will be very broad, and will cover the entire subject from a number of points of view. It is probable that this series will be continued for eight or ten months in order that the ground may be covered so thoroughly as to make a complete treatise on the subject.

The Japanese Naval Victory.

With the complete annihilation of the Russian Baltic Sea fleet and the practical sweeping of the Russian navy from Asiatic waters, Admiral Togo has won a naval victory which has been almost unparalleled in history. That this tremendous result should have been achieved in the face of an enemy almost equal in strength to his own fleet, and without the loss of a single ship of any importance, is certainly very remarkable. It brings to mind, especially to American thinkers, the two great naval victories which marked the course of our late successful war with Spain, and deprived the last-mentioned power of all of her American and Asiatic colonies. Admiral Togo appears to have lost several hundred men from his fleet, which is in startling contra-distinction to the American loss in Manila Bay and at Santiago, which numbered respectively eight men wounded in the one case, and one man killed and two wounded in the other. But it may be said in this connection that the disparity in force between the two fleets in combat was much less than was the case at Santiago, and probably than was the case in Manila Bay.

It had been generally expected that Admiral Togo would either have allowed the Russian fleet to reach Vladivostok and there be cooped up, much as was the other Russian fleet at Port Arthur; or that he would have endeavored, by a series of night torpedo attacks, or some other distracting method, to scatter portions of the Russian fleet, or perhaps cut off certain detachments, which could then be overpowered in detail, in accordance with the time-honored policy adopted on land by Napoleon. That he adopted neither of these policies has been the cause of considerable surprise, inasmuch as any ill-fortune attending his ships in such a battle as was waged might have resulted very disastrously, not only to the future conduct of the present war, but also to the entire future history of the Japanese Empire, and of the section of the Asiatic mainland immediately contiguous to the theatre of hostilities. He seems, however, to be a complete master of the difficult game of strategy, this mastery involving necessarily an intimate knowledge, not only of the potentialities and the limitations of his own force, but in an equal degree those of the enemy as well.

His success seems to have been the result of much the same elements as contributed to the success of the American navy seven years ago this summer. These elements may be briefly outlined as consisting in thorough discipline, a lively appreciation of the necessities of the case among both officers and men, a spirit of friendly rivalry among the various ships as to the efficiency in which they could be maintained, and the results which could be accomplished against the enemy, and above all to the admirable gunnery exhibited in all cases, the sort of attribute which gave rise seven years ago to the memorable expression "the man behind the gun." In distinct contrast with this situation, we have seen the Russian fleet go into a panic when encountering a fleet of fishing craft at night. We have seen them lie inactive for months, awaiting reinforcements and provisions; and though this latter period was generally supposed to have been occupied to a considerable extent in gunnery practice and in preparations generally for the mortal combat which it was recognized they would have to wage at the conclusion of their long journey, these preparations do not appear to have borne fruit in results, for the gunnery is reported to have been decidedly wild, nearly all of the shot having passed completely over the Japanese vessels at which they were aimed, in many cases striking ships far in the lee of the battle line,

and doing considerable damage at points very remote from the immediate object of attack. This peculiar inability to keep the shot down to the hulls of the enemy's ships was a prominent characteristic of the fire of the Spanish ships at both of the naval battles above mentioned. It was also characteristic of the fire of the English ships in nearly all the naval duels of the war of 1812, and it is to this wildness that we can attribute in large measure many of the American victories of that conflict; while the Americans had been trained to bring their guns to bear in such a way as to hit the hull of the enemy, the British appear to have done their utmost to damage the sailing power; and the inevitable result of heavy loss in the personnel of the British crews and light loss among the American crews has been repeated at this distance of nearly a century in the only two wars which have given an opportunity for the testing of modern war appliances of the heaviest type. Thus we have once more an exemplification of the truism of the old adage—"History repeats itself."

At the present writing, the eyes of the whole world are centered upon the Russian and Japanese governments in earnest expectation of a deliberate move toward peace. The destruction of the Russian armada having made it impossible for the Russian government to maintain war except by relying solely for communication upon the Transiberian railway, and by confining the sphere of activities to northern Manchuria and the immediate neighborhood of Vladivostok, it has seemed to outside observers that with the continual record of ill-success met by the Russian armies in their campaigns against Nogi and Oyama nothing could be gained by a further prolongation of hostilities; and that, onerous though the Japanese terms will doubtless prove to be, they will be less difficult to meet than would be the case at the conclusion of another victorious campaign. The Japanese appear to be perfectly willing to make peace on reasonable terms, although some sentiment in that country seems to be in favor of pushing to the utmost the advantage they now have, before ceasing operations. It is to be hoped, however, that they will be content with the marvelous success which they have thus far achieved, and will be sufficiently lenient in their demands to present claims which the Russians can accept, and thus end a conflict which has lasted already about seventeen months, has cost an immense number of lives and tremendous resources of a financial character, and has solved the problems and cleared the issues for the solution and determination of which it was undertaken.

The Yacht Race.

Our congratulations are due to the designer, the owner and the skipper of the victorious *Atlantic*, winner of the Kaiser's cup. The magnitude of the victory makes it all the more gratifying to Americans that an American yacht, designed, built and owned by Americans, and sailed by an American citizen, should have so signally proven her superiority over all rivals. It recalls the memorable days of the old *America*, of more than a full half century past, and shows that, despite the influences which have resulted in all but sweeping the American flag from the high seas, we have not yet entirely lost the "sea habit."

Some More Appreciation of the Situation.

At the tenth annual convention of the National Association of Manufacturers, which was held at Atlanta, Ga., about the middle of May, the following resolution was unanimously adopted:

"Whereas, This Association has annually, for several years, pleaded for the restoration of a merchant marine, now imperative and indispensable for our present and future commerce, our exports having reached a total of nearly a billion and a half, and our imports over a billion, and still increasing; and

"Whereas, Our flag has almost entirely disappeared from the high seas, ninety-two percent of our entire foreign commerce having been transported in foreign-built vessels in 1903, and over ninety-five percent in 1904, including naturalized steamships under American registration; and

"Whereas, At the fifty-eighth Congress a Committee was created for the purpose of investigation and reporting upon the merchant marine necessities of the United States; therefore, be it

"Resolved, That the National Association of Manufacturers commends the work of the Merchant Marine Committee, heartily approves the passage of a bill for the upbuilding of American shipping in the foreign trade—for our passengers, mails, and war service, and requests Congress promptly to take action on such a bill, thereby making possible an American maritime power for the present and future expansion of our great commerce and as an auxiliary to our Navy."

At a dinner of the Business Science Club, held June 13, Mr. Ralph W. Grout voiced the sentiments of a large number of thinking Americans when he said:

"Do not compel us to use ships subsidized by foreign countries and sailing under foreign flags in the building up of our foreign trade. Give us American ships owned and sailed by Americans; fostered, protected and subsidized by the Government, under such conditions that our manufacturers and merchants may embark in the enterprise. While we are on this subject we will do well to remember the words of our President, that a first class navy is a very good thing to have handy for the protection of our rights upon the high seas and in the command of courtesy and respect where necessary, to say nothing of the protection it might be to our shipping and merchant marine, when the time comes that we have one."

We heartily concur in these sentiments.

THE DESIGN OF MARINE MACHINERY.

BY W. F. DURAND.

PART V.—*Continued.*

A careful study of these various paths, all of which were taken from a model representing normal proportions, together with others representing the results of other modifications, will serve to establish the following abstract of tendencies in the various cases:

(1) For case (1) in general, the curves showing paths of P are elongated or pointed ovals passing through narrow figures of 8 and into broad, open ovals at the extreme positions of S in vertical range. For low positions of S the figure is an oval with point at the top or a figure of 8 with the cross near the top and the large lobe of the 8 below. As the center S moves up the cross point moves down and the 8 narrows, passing through a nearly symmetrical narrow figure, beyond which it again widens as the cross point approaches the lower end, and beyond which it opens out into a pointed or open oval with point or smaller end down. In the meantime, the figure also rotates as a whole in such direction as to carry the upper end away from the link.

For a shift in the position of R from the concave side across the line of the arc to the convex side the rotation of the figure is but slight, but the oval changes rather quickly from point down to point up, or in the general direction corresponding to a movement of the cross point upward.

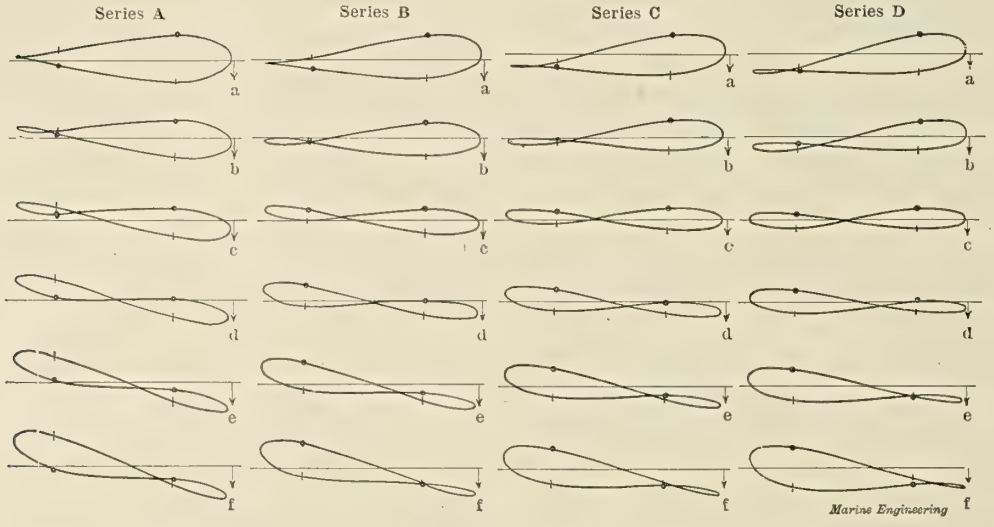


FIG. 32.—OVALS SHOWING PATHS OF GO-AHEAD END OF LINK, CASE (2). IN EACH CASE THE UPPER END OF THE PATH IS DENOTED BY THE SMALL ARROW, WHICH POINTS TOWARD THE BACKING END OF THE LINK.

For a change in the length of bridle rods the effects on the paths are usually slight. Very commonly the least width of figure, and hence the least possible block slip, will be given by the shortest practicable length of bridle rod, the points S and R being at the same time appropriately taken, the former in vertical range and the latter relative to the link arc center line.

For linked up positions of the gear the same general changes are met with, the figures themselves being gradually reduced in length and usually in amplitude, but with some tendency to rotation depending on the path of S relative to the vertical direction.

For a series of positions of the link covering the entire range from full gear ahead to full gear back, it is usually found that for the minimum amount of block slip the point S should follow a curved path, concave viewed from below, and hence opposite to that given by two usual locations of the rock-shaft above the level of the link, as in Fig. 29.

(2) For case (2) in general, the paths are figures of 8 passing into ovals at either extreme. For low positions of S the figure is an oval with point down. As S moves up the cross point appears and moves up also, while the figure rotates in such direction as to carry its upper end toward the link. For a shift in the location of R from the concave side of the arc across to the convex side, the figure rotates in somewhat pronounced manner in such direction as to carry the upper end of the figure away from the link, while the general character of the oval or cross point of the 8 changes more slowly, the latter moving upward.

For a change in the length of bridle rods the changes are but slight. As a rule the narrowest figure and best results as regards amount of block slip are obtained with the longest practicable length of bridle rod, the points S and R being at the same time appropriately taken, the former in vertical range and the latter relative to the link arc center line.

For linked up positions of the gear the same general changes are met with, and the same general remarks apply as for case (1).

(3) For case (3) the changes in the path of A with vertical change in S are readily followed without special discussion. For moderately linked up positions the paths are elongated ovals bent around in the same general sense as the arc followed by A. It is not customary in this case to vary the point of attachment relative to the link arc center line. The points R and A become in this case coincident.

Let us now turn to another point of the discussion and refer to Fig. 30. This shows that when the block is made fast in the link and one point of the latter is thus guided in the line of motion of the valve, the center of the link moves in a generally elongated oval or 8, bending around away from the go-ahead end of the link. Now, it will be clear that if the point R is taken at the center of the link and the bridle rods are carried out past the backing end as for case (1), then the center of the link will be guided in the arc of a circle convex to the go-ahead end, and therefore having its curvature in the same general direction as that of the oval h of the figure. On the other hand, if the bridle rods are carried out past the go-ahead end, as for case (2), then the center of the link will be guided in the arc of a circle concave toward the go-ahead end, and therefore having its curvature opposite to that of the oval h in the figure. It is readily seen that the path of the center of the link with the arrangement of case (1), as shown by the arc EF, will be a better approximation to the curved oval than with the arrangement of case (2), and we find here the reason for the narrower resultant figures and reduced block slip with the arrangement of case (1).

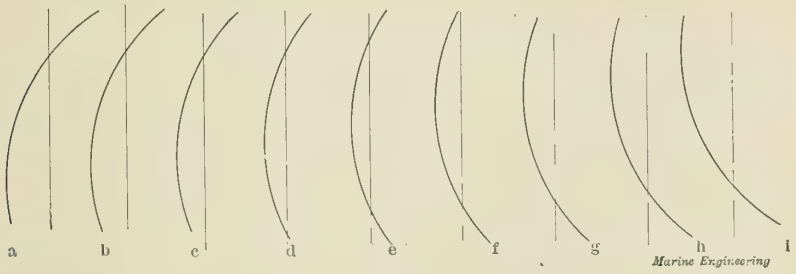


FIG. 33.

Let us now turn to another point of the discussion and examine the paths shown in Figs. 31, 32, with reference to the general standing of any given case with respect to the influence of block slip on the equalization of cut-off in the two ends of the cylinder, or the increase of lead at the bottom as compared with the top.

In each case the location of the point A at the opening of the valve is indicated by a dot and at closure by a small cross line. In Fig. 31, for case (1), the link lies to the left of the oval (above in the diagram) in any given instance, and it will be readily seen that for a tendency toward the equalization of the two points of cut-off the line joining the two corresponding marks on the oval should lie inclined toward the link at the top, while in order to give a relatively increased lead at the bottom the line joining the two points on the oval for steam opening should lie inclined away from the link at the top. It is readily seen whether or not these conditions are fulfilled, and to what degree.

Similarly in Fig. 32, for case (2), the link lies to the right of the path (below in the diagram), in any given instance, and it will be seen that for a tendency toward equalization of the two points of cut-off the line joining the two corresponding marks on the oval should be inclined toward the link at the top, while for a relative increase of lead at the bottom the line joining the two points on the oval for steam opening should lie inclined away from the link at the top. These conditions are thus seen in general to be the same for the arrangements of both cases (1) and (2), and are fulfilled or violated in varying degrees as indicated by the various paths in the two sets of series.

An examination of these various paths will show that the arrangement of Fig. 31 will give a reduced block slip with corrections for cut-off and lead in the right direction more readily and more effectively than the arrangement of Fig. 32, and this fact furnishes an added reason

for the general preference which is given to the arrangement of case (1) as compared with case (2).

An application of these same general principles to the arrangement of case (3), the paths for which are shown in Fig. 33, will show that but one of the two conditions can be fulfilled with any one arrangement of the gear, and that if the center S is relatively low the cut-off correction will be in the right direction while the lead correction will be wrong. Similarly if the center S is high the lead correction will be in the right direction while the cut-off correction will be wrong.

It is furthermore seen that no matter what the arrangement of gear if the path of A is so nearly symmetrical that the lines joining the points corresponding to cut-off and steam opening are sensibly parallel to the line of valve motion, as in Fig. 32, series D, oval C, then of course there is no correction for either cut-off or lead due to the influence of block slip.

It is furthermore seen that so far as these corrections are concerned, precautions should be observed as follows:

For case (1) the point S should be low rather than high.

For case (2) the point S should be high rather than low.

For case (3) the point S should be low or high, according as correction for cut-off or lead may be considered the more important.

The discussion thus far has had sole reference to a valve gear with outside valve; or to the case in which the movement of the valve *above* mid position determines the flow of steam through the bottom port and the events for the up stroke, and vice versa *below* mid position for the upper port and down strokes. In the case of an inside valve the movement of the valve above mid position determines the flow of steam through the upper port and the events for the down stroke, and vice versa for the bottom port and up stroke. If the gear is still of the "open rod" configuration—that is, with the rods open when the eccentrics are turned *toward* the cylinder—then the various ovals for the working end of the link will be the same as for an outside valve, but with opposite relations to the ends of the stroke. Thus, in Figs. 31, 32, the ends of the ovals where the arrow is found will relate to the down stroke and the opposite ends to the up stroke. From these reversed relations it will result that the tendencies with respect to equalization of points of cut-off or to a difference in lead will be also reversed, and that for a tendency in the direction of more equal cut-off the line joining the corresponding two points on the oval should be inclined away from the link at the top and for a tendency toward a relative increase of lead on the bottom end the line joining the corresponding two points on the diagram should lie inclined toward the link at the top, as in series D, oval b. It is readily seen that in general these conditions are less readily fulfilled than for the outside valve, and hence, that the inside valve is at a slight disadvantage as compared with the outside valve in respect to this particular feature of valve-gear adjustment.

(To be continued.)

ABSTRACTS FROM RULES AND REGULATIONS OF THE AMERICAN BUREAU OF SHIPPING FOR OIL-TANK VESSELS ONLY.—Continued.

EDITION OF 1904.

ARRANGED BY HARRISON S. TAFT.

4. The horizontal stiffeners are to be of the plate, knee bracket (spaced not over two frame spaces apart) and face angle type as for athwartship bulkheads. They shall be worked in way of the horizontal stiffeners on athwartship bulkheads, to which they shall be bracketed. When the horizontal stiffeners on a longitudinal bulkhead are in the same tank as the vertical stiffeners on an athwartship bulkhead, said horizontal plate stiffeners are to have a double clip and bracket-plate connection to the athwartship bulkheads; with 5 rivets in each side of the brackets when the second number is under 19,000, but 7 rivets when the second number is or over 19,000.

5. Said longitudinal bulkheads are to have a single double-riveted angle bar, or double single-riveted angle bars on top to form the connection to the "crown deck" or to the top of the expansion tank. The flanges of said bars are to equal the bulkhead plating to which they are attached.

6. When a hold is over 20 feet in length a web plate stiffener as above (17-A-4 b) is to be worked at the center of said space.

7. When the machinery is located amidships the longitudinal bulkhead aft of the machinery space is to be connected to the top of the shaft tunnel with double angle bars, double riveted to the bulkhead plate. Or it may form one side of said tunnel, in which case the horizontal floor-plate stringer at the center line must be wide enough to be secured to said bulkhead plating with an angle bar double riveted in both flanges.

8. (*a*) The ends of a longitudinal bulkhead should extend through the cofferdams and thence taper for four frame spaces to the top of floors. The edge of the tapering part is to have double angle bars equal to the reverse

bars of an ordinary ship. Vertical stiffeners of similar scantling are to be spaced one frame space apart on each side.

(*b*) When the machinery is fitted amidships the forward end of the aft longitudinal bulkhead should extend through the cofferdam, and be securely fastened to the bulkhead at the aft end of the engine room. A web plate stiffener one frame space wide at the deck, tapering thence to the width of the stiffener angle at the bottom, is to be worked on the forward side of said bulkhead in way of above the longitudinal bulkhead. Said web is to extend from the top of the tunnel to the "crown deck," and it shall be equal in weight to the lower part of the bulkhead plating. It shall have a double face angle of the same scantling as those on the diagonal edge of the longitudinal bulkhead at their ends.

9. When the machinery is fitted amidships, fore-and-aft bunker bulkheads should be worked throughout said machinery space in the wings; or the keelsons should be increased in number and strength, with girders at the main deck, to compensate for the loss of strength due to the discontinuance of the center-line bulkhead.

10. Laps of all bulkheads in the tanks and of the shaft tunnel plating should be caulked on both sides.

11. Sluice valves, doors, etc., will not be allowed below the "crown deck."

18. Shaft Tunnel.

1. The entrance to said tunnel is to be from the upper deck at each end of the tunnel.

2. Tunnels are to extend through the cofferdams at each end. They are to have angle-bar connections, double riveted in both flanges to the bulkheads at the ends of the tunnel. The tunnel plating is to equal the lower part of the bulkhead plating. The flanges of the above angles are to equal the tunnel plating.

3. Stiffeners, equal to the frames of ordinary vessels, are to be worked at every frame, with close spacing of rivets, so as to provide for caulking said stiffeners.

4. The tunnel floor is to be plated, having a single angle-bar connection double riveted in both flanges to the plating forming the side of the tunnel.

19. Shell Plating.

1. The shell plating is to be of the same scantling as for an ordinary vessel, except for a flat plate keel.

2. When the machinery is located aft, the midship scantling of all plating below the numerical deck is to be maintained aft to the stern post, including the upper deck sheer strake, and all plating below it in vessels built under the three-deck rule.

20. Inner Bottoms.

1. Inner bottoms may be worked in the machinery space for water-ballast purposes.

2. They should be of a type having solid floors on every frame connecting to the inner bottom plating; or with girders on top of floors.

3. The top bars on the center-line keelson are to be 10 percent heavier than for ordinary vessels.

4. When the "solid floor plate" type of construction is used, the number of keelsons (see 17-9) need not be increased, but the longitudinal girders must be connected to the inner bottom plating with double angle clips.

5. If the "girders on top of floors" type of construction is used, they are to be spaced as in ordinary vessels, but are to be heavier as specified. Unless connected to the intercostal floor keelsons, they are to have a continuous double angle bar on the lower edge connecting them to the reverse bars and clips on top of the floors. They are to have an extra-heavy single angle bar connection to the inner bottom plating. When the second number is 42,000 or over, a horizontal plate stringer is to be worked on top of floors under said girders, said stringer plate being of the said weight, but in breadth 1-2 the depth of the floor plates of ordinary vessels.

6. The frame brackets and web frames are to have double clips to the margin plate. The frame brackets are to equal the weight of the web frames. The gusset plates, etc., are to be the same as in ordinary vessels.

7. The inner bottom plating strakes in way of the regular keelsons should extend through the cofferdams with a taper, and have an angle-clip connection to the bulkhead at the end of said taper.

21. Expansion Tanks.

1. When said tanks are worked at the sides of the ship, the continuous gunwale bar of the "crown deck" outside of said tanks should have a welded knee at said tank and be worked continuous around said tank, so as to connect the same to the deck plating; with both flanges double riveted throughout. The plating of a side tank is to equal that of the middle plating of the bulkheads.

2. When said tanks are at the center line of the ship their plating is to equal that of the upper part of the bulkhead plating. Said plating shall have a double-riveted flange or a single-riveted angle bar, double riveted in both flanges, connection to the "crown-deck" plating, with a similar angle-bar connection to the upper deck.

3. The stiffeners are to be equal to the frames of ordinary vessels. They are to be spaced at each frame and be bracketed at the top and bottom to the deck beams, with a 4-rivet connection to both beams and stiffeners.

4. When the hatchways are located at the sides of the expansion tanks, the tank plating at the "crown deck" may be worked so as to form the coaming of said hatchway. In which case said plating at the hatchway is to equal the weight of the upper-deck stringer of ordinary vessels, extending from the lower side of the "crown-deck beams to one foot above said deck, being double riveted to the regular tank plating. The "crown-deck" plating for two frame spaces at the fore-and-aft ends of said hatchway and of one deck strake at the side of said hatchway are to be 5 pounds heavier than otherwise.

5. When the hatchways of the upper deck, which are at the sides of the expansion tank, are 8 feet or more in length, they should be constructed as above, with the coaming plate extending below the upper deck beams so as to allow of a double-riveted lap to the trunk plating.

When the length is under 8 feet, the trunk plating may form a combined fore-and-aft and hatch coaming.

A metal oil-tight hatch cover should be fitted to each hold on top of the expansion trunk. Means should be provided for readily ascertaining the depth of oil in any hold.

22. Ventilation, etc.

Means must be provided for a thorough ventilation of all oil tanks, cofferdams, shaft tunnels, double bottoms, machinery space, coal bunkers, and all other compartments. Electric lights only will be allowed in oil vessels.

23. Butt Straps.

1. The butt straps of the flat plate keel; web frames; and side stringers are to be worked double. They shall be at least 5-8 of the thickness of the plates they connect.

2. The butt straps of the center-line keelson and of all deck stringers are to be worked double. They shall be at least 3-4 of the thickness of the plates they connect.

3. The butt straps of the middle-line horizontal floor stringers are to be worked single. They shall be at least 3 pounds heavier than the plates they connect.

4. Triple-riveted butt straps of the "crown-deck" plating are to be worked single. They shall be at least 5 pounds heavier than the plates they connect.

5. Butt straps of the shell plating are to be worked double. The outside ones are to be at least 5-8: the inside ones at least 3-4 of the thickness of the plates they connect.

6. Bosom pieces are to be of the same flange thickness as the angles they connect.

24. Riveting.

1. Rivets of less than 3-4 inch in diameter are not to be used in any part of the ship subject to an oil or other liquid pressure; except in expansion trunks, where 5-8 rivets may be used if the trunk plating is less than 14 pounds. The deep frame connections to the frames are to have at least 3-4 rivets spaced 6 diameters apart.

2. Pan or plug-neck rivets are to be used in all work subject to oil pressure. In tank bulkheads where the pressure comes on both sides, counter-sunk points as well as counter-sunk heads are to be used. All rivets in bracket plates, butts, and angles of side stringers, and web frames are to be finished peen fashion.

3. The Following to be Single Riveted:

(*a*) Laps or seams of the expansion tank plating.

(*b*) Laps or seams of the tank bulkhead plating when the depth to top of the "crown deck" from top of floors is under 13 1-2 feet; or the second number is under 19,000.

4. The Following to be Double Riveted:

(*a*) Laps or seams of the shell plating.

(*b*) Laps or seams of the shaft tunnel plating.

(*c*) Laps or seams of the "crown-deck" plating.

(*d*) Laps or seams of all bulkhead plating to the floors and to the center-line keelson in all cases.

(*e*) Laps of the expansion-tank plating when flanged to the "crown deck."

(*f*) Laps or seams of all tank bulkhead plating when the depth from top of floors to top of the "crown deck" is 13 1-2 feet or over; or the second number is 19,000 or over.

(*g*) Laps and butts of the inner bottom plating; except the center-line strakes.

(*h*) Butts of the "crown-deck" plating when the second number is under 72,000.

(*i*) Butts of the expansion-tank plating.

(*j*) Bulkhead frames in both flanges.

(*k*) Gunwale bars of the "crown deck."

(*l*) Bounding angles to the expansion tanks.

5. The Following to be Triple Riveted:

(*a*) Butts of the flat plate keel.

(*b*) Butts of the center-line keelson.

(*c*) Butts of the web frames.

(*d*) Butts of the side stringers.

(*e*) Butts of the horizontal floor stringer at the center line throughout.

(*f*) Butts of all the deck stringers.

(*g*) Butts of all the shell plating. They are to have three full rows of rivets.

(*h*) Butts of all the "crown-deck" plating when the second number is 72,000 or over.

(*i*) Butts of all center-line strake of the inner bottom plating.

6. Double Zigzag Riveting to be Used as Follows:

(*a*) Both flanges of a transverse tank bulkhead frame bar and bounding angle.

(*b*) Both flanges of the "crown-deck" gunwale bar.

(*c*) Bulkhead stiffeners which are to be caulked.

(*d*) Water-tight staple work at the keelson and side-stringer junction with all bulkheads.

(*e*) Both flanges of the expansion tank corner bars.

(*f*) Both flanges of a single bar connection of a transverse to a longitudinal bulkhead.

(*g*) Both flanges of the coaming bars to the expansion tank and deck plating.

7. Bosom Pieces.

(*a*) Those to the center-line keelson and side-stringer angle bars are to have three rivets on each side of the butt.

(*b*) Those to the reverse bars, 4 rivets on each side of the butt.

(*c*) Those to the deck gunwale bars, 3 rivets on each side of the butt.

8. All frames are to have at least a 3-rivet connection to a flat plate keel.

9. Reverse clips on the floors or frames at all keelsons, stanchions, and side-stringer angles are to have at least a 4-rivet connection to the floors or the frames.

10. Reverse clips on the web frames at the diamond plate connection to the side stringers are to have at least 3 rivets in each of the clips to the web frame.

11. Distance between rows of double or zigzag riveting is to be the same as for ordinary vessels.

12. All rivets in the bulkhead bounding bars; bulkhead shell liners; and all bounding bars in the oil-tank spaces should be caulked.

25. Spacing of Rivets.

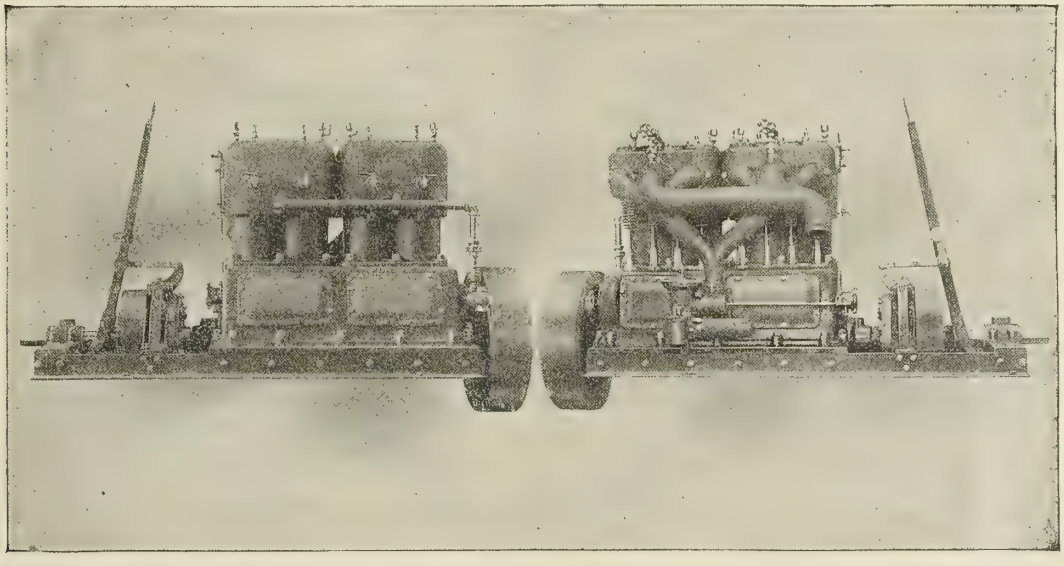
		DIAS.
1. Double chain riveting		3¼
2. Double zigzag riveting for oil-tight work (each row)		4
3. Single riveting of laps or angles for oil-tight work		3
4. All bracket plates; knees; non-watertight clips; clips not connected to the shell plating,	Single riveting	4
	Double and zigzagged.	5
5. Middle-line keelson angle bars; clip connecting side stringers and keelsons to the shell plating,	Single riveting	3¾
	Double and zigzagged.	4¼
6. Ordinary frames to shell plating; reverse bars to floors; web frames and frames; deck plating to beams; bulkhead and expansion-tank stiffeners not caulked; keelson and stringer running angles not caulked; web plates to frames; deep frames to frames,	Single riveting	6
	Double and zigzagged.	7½

Note.—For Riveting Table see Table 18, on page 221.

ENGINEERING SPECIALTIES.

A New Type of Two-Cycle Engine.

The engine which we illustrate on this page has been placed upon the market by the Racine Boat Manufacturing Company, of Muskegon, Mich., and is controlled by one lever which simultaneously handles the reversible propeller wheel, the spark commutator, and the throttle on the carbureter. By this means a constant speed on the engine is maintained no matter what the load, so that when placed on a launch the speed of the boat may be varied to suit any requirements up to the maximum of which the engine is capable, going either ahead or astern. The carbureter is of a special type in which the usual noisy compensating valves and springs are omitted, and is the direct outcome of a large amount of experimentation. The engine is made with one, two, or four cylinders.



Cook's Metallic Packing.

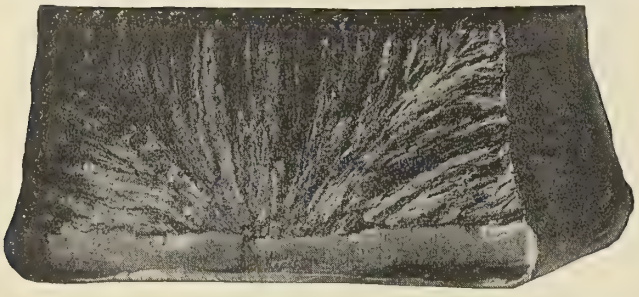
One of the most trying difficulties before the successful operation of metallic packing on vertical engines has been the complete arresting of condensation. This, if it is not entirely controlled, is a very troublesome thing, with reference to wrist pins, journals, commutators, etc. In Cook's standard vertical double metallic piston-rod packing, made in Louisville, Ky., this has been accomplished by means of placing two sets of metallic packing together. The upper or main set serves to hold the steam pressure, while the lower set catches water and conveys it off through the threaded opening of the lower gland. If desired, a drain pipe can be screwed into this gland and led to any convenient place. This packing is also used in extra heavy duty service, though, in such instances, the drain pipe and opening in gland are omitted, thus working both sets of packing under pressure.

A New Bearing Metal.

Although there are on the market a number of metals for bearing purposes for which claims of superiority are made, the metal illustrated by the accompanying cut is said to possess more than usual features of interest. The manufacturers have given it the name of Fibro metal, the cognomen being derived from the fibrous quality which a fracture reveals in its structure. The composition is of a tin and aluminum base, and the fibre has the remarkable characteristic of radiating always from the chilling surface.

In the case of wood it is known that the end of the fibre is much stronger in resistance than the side, and that it will stand a greater amount of sliding friction as well as crushing weight. This was the principle for which the metallurgist who is responsible for this alloy worked, and his efforts were extended over a period of twenty years. A close examination of this metal

shows it to be so fine in texture, with no granular matter intervening, that it might be called a truly chemical compound—not a combination of metals, but a new metal in itself. Ordinarily metals of this class will not admit of remelting and being used over again, owing to the grosser metals in the composition (those which melt at the lowest point) volatilizing and burning up before the finer metals begin to melt. This makes the alloy harder and harsher with each melting, and renders it quite useless. Fibro may be remelted as often as desired, and will retain all the

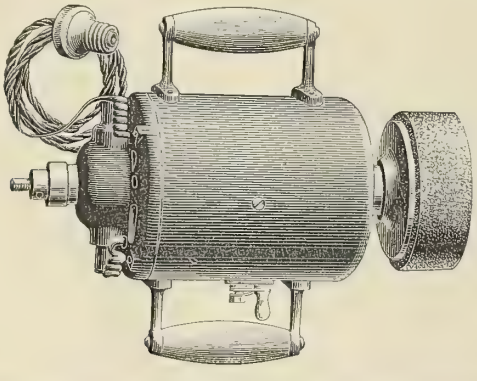


original qualities. Its toughness and malleability permits it to stand the severest shocks without becoming brittle. Under a steam-hammer test it has been pounded out to 1-3000 of an inch, and could be beaten much thinner by hand.

The Buda Foundry and Manufacturing Company, of Chicago, who are the manufacturers of this metal, are offering it as being particularly adapted for ships' bearings. Certain it is that this new alloy has features of interest, and the claims made for it are well worth investigating.

Portable Electrical Hand Grinder or Sander.

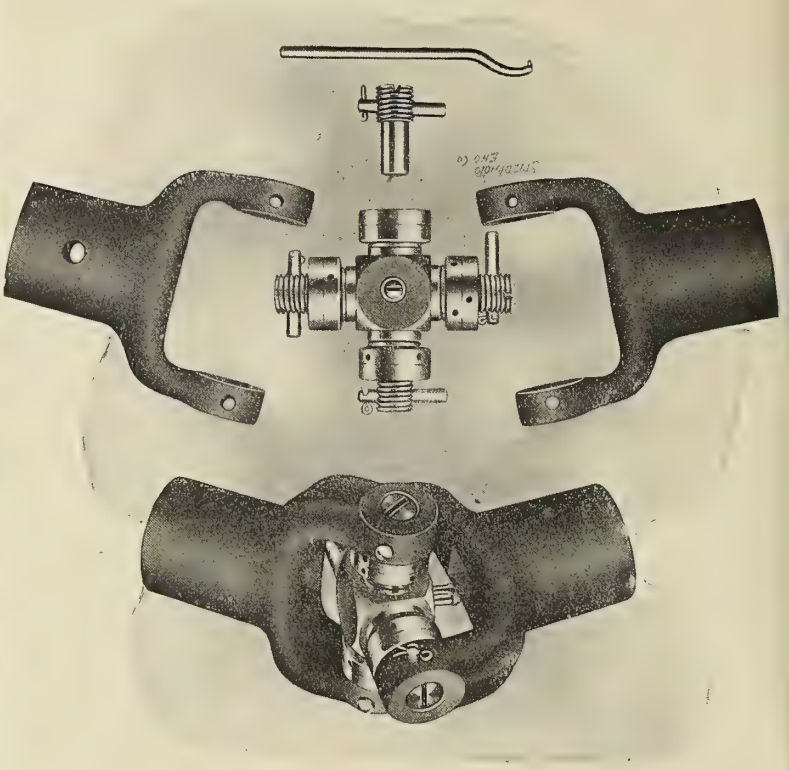
We here illustrate a new tool recently put on the market by the Hisey-Wolf Machine Company, Cincinnati, O. It is a handy little machine and adaptable for grinding, buffing, polishing, sanding, or other work of this nature, as any kind of wheel can be attached, according to the work to be done. The driving power is obtained from the ordinary incandescent lamp socket, direct current. This tool is light in weight and can be carried anywhere, as any length cord can be used.



The motor is enclosed and dust-proof, and the bearings are adjustable to wear. It is under the immediate control of the operator at all times by means of a switch at the handle. Two handles are located diametrically opposite, enabling the operator to hold it firmly and to manipulate it to advantage. The tool is made in two sizes of about 1-4 horsepower and 1-2 horsepower, weighing 14 and 22 pounds respectively. An adjustable extension spindle of about 5 inches is furnished if desired. The value of this tool can be readily recognized, and the builders send it subject to trial to all possible users.

An Adjustable Self-Oiling Universal Joint.

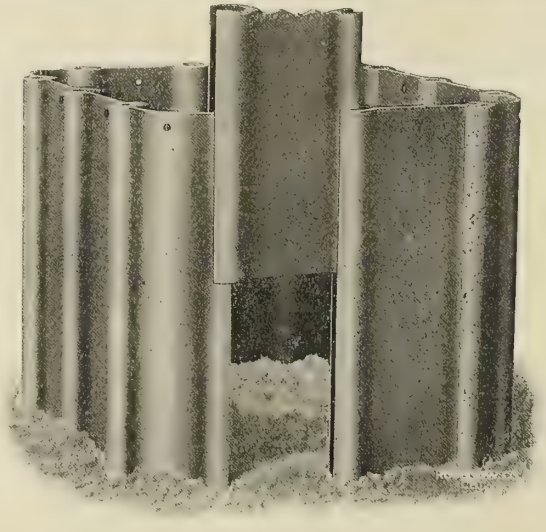
The universal joint, which we illustrate, is manufactured by the Baush Machine Tool Company, of Springfield, Mass., in sizes capable of transmitting from 5 to 50 horsepower. It is said to



be strong and durable, besides being very simple in construction. It is self-oiling and adjustable for wear. The forks are made of steel castings and the transmission spool or block of bronze, the latter being bored through from end to end of the projecting arms to receive the trunnion screw, leaving in the center an oil reservoir. The diameters of the joints vary from 1-4 inch to 4 inches, dependent upon the amount of power to be transmitted.

A New Steel Sheet Piling.

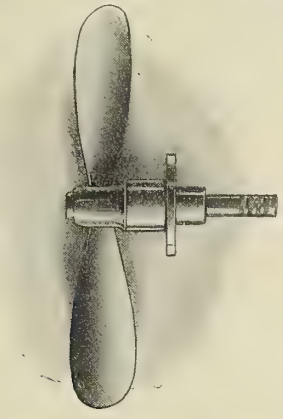
This piling is a plain rolled section, complete in itself, without bolts, rivets, or other attachments, and is ready for use as it comes from the mill, for all purposes for which sheet piling can be used. It is made absolutely watertight by packing the grooves with mud, clay, or any suitable material at hand, and is unequaled for dams, cofferdams, locks, or work where water-tightness is a necessity. The intersliding and interlocking features are perfect, and prevent the pulling apart edgewise or the turning laterally of the adjacent pile. The flat web and cylindrical ribs give great strength and offer the least resistance in driving or drawing. There are no bolts or rivets to shear off, and no auxiliary parts to become lost



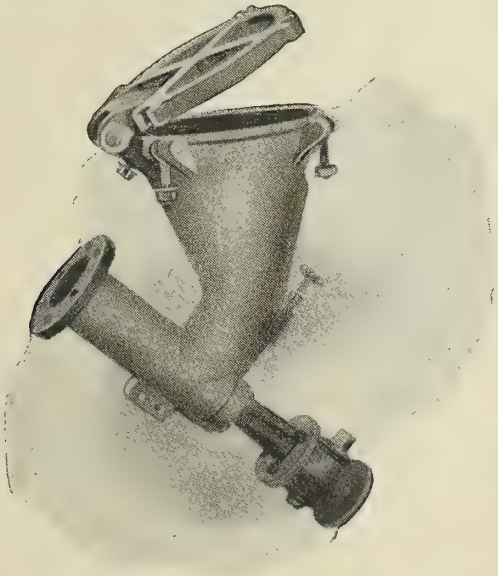
or damaged. The interlocking arrangement is self-contained; the alignment is perfect; the piling is balanced as to its center lines, and minimizes excavation. There are no angles or corners; the rounded ribs make it unsurpassed for wharves and docks. Each pile is complete in itself and is interchangeable. It is rolled in sections weighing 35 pounds and 40 pounds per foot, measuring 12 inches from center of large groove to center of small groove, and in lengths as required. The manufacturers are the United States Steel Piling Company, of Chicago.

The Spaulding Reversible Propeller.

Much of the trouble arising from the ordinary forms of reversible propellers is traceable to obstructions lodging in the sleeve tube which operates the reverse mechanism, and to the failure of the hub to withstand the wear and tear due to the collection of sand and other *debris* at this point. To overcome this objection



the Spaulding Gas Engine Works, of St. Joseph, Mich., employ a propeller which has a solid shaft to operate the reverse, thus eliminating completely the use of the sleeve tube and throwing the strain of the thrust upon the stern bearing, and ultimately upon the skeg of the boat, thereby relieving from all strain the engine and the engine bed. This device is said to be absolutely dirt and grit proof and to work very satisfactorily.



New Hydraulic Ash Ejector.

This ejector, which is placed on the market by the Marine Manufacturing and Supply Company, 157 South street, New York, is stated to be capable of ejecting a larger amount of ashes on a given consumption of water than any other similar instrument made. The auxiliary nozzle shown at the right of the illustration carries a stream of water down the side of the hopper, thus clearing the same and assisting the formation of the main jet vacuum by filling the discharge opening with water. With a water pressure of 125 pounds per square inch, this ejector will take care of ashes as fast as two men can shovel them into the hopper.

TECHNICAL PUBLICATION.

Mechanics of Air Machinery. By Dr. Julius Weisbach and Professor Gustav Herrmann. Translated by Amasa Trowbridge, Ph.B., Columbia University. Pages 206; figures 91; two folding plates. New York: D. Van Nostrand Company, 1905. Price $3.75 net.

The first part of this book takes up the movement of air in ventilation and goes into both natural and artificial methods of ventilation, with a considerable amount of material on the theory of the subject. The next section, which is by far the largest in the work, is devoted to blowing machines, and treats of vacuum pumps, tuyeres, and various problems connected with the design and operation of systems for hot-air blast and all sorts of purposes for which blowing engines are used. Another section treats of air compressors, while the last two are devoted respectively to rotary blowers and fans. The appendix, by the translator, covers about fifty pages, and is taken up with a discussion upon recent American practice in this field. The latter part of the work is profusely illustrated with both half-tones and line cuts, and is rather a review of the general field than any attempt to enter into the theory of the subject, such as is discussed in the original work in German. As is almost universal with works in the German language, the theory is very largely concerned with mathematical formulæ, involving both rational and empirical expressions concerned with the flow of air, and its control for useful purposes.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 294.—Please answer the following questions regarding good practice in the design of four-cycle marine gasoline engines:

(*a*) What is the proper mixture of gasoline and air?

(*b*) What is the heat of combustion?

(*c*) What is the specific heat of the products of combustion?

(*d*) What is a proper velocity to use in designing inlet and exhaust passages? C. R. S.

A.—(*a*) A very common mixture would be one volume of gasoline vapor to five of air.

(*b*) The heat of combustion is given as 600 B.T.U. per cubic foot of mixture. The temperature of combustion is estimated at 6,380 degrees Fahrenheit.

(*c*) The specific heat of the products of combustion are given as .206 at constant volume, and .28 at constant pressure.

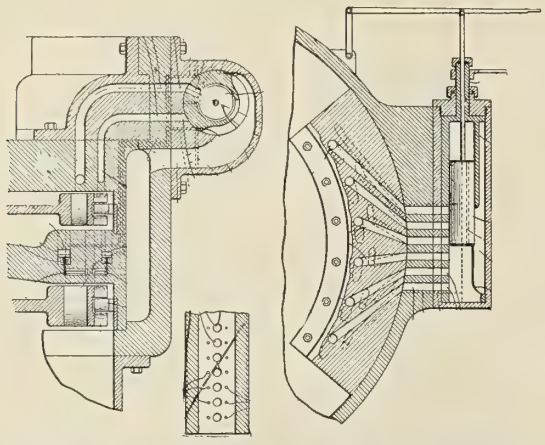
(*d*) The velocity usual in designing inlet passages is 60 feet per second where automatic valves are used, and 90 feet where the valves are operated by external mechanical means. For exhaust passages the velocity of discharge is usually figured at 75 feet per second.

The above information is taken from Hutton: *The Gas Engine.*

SELECTED MARINE PATENTS.

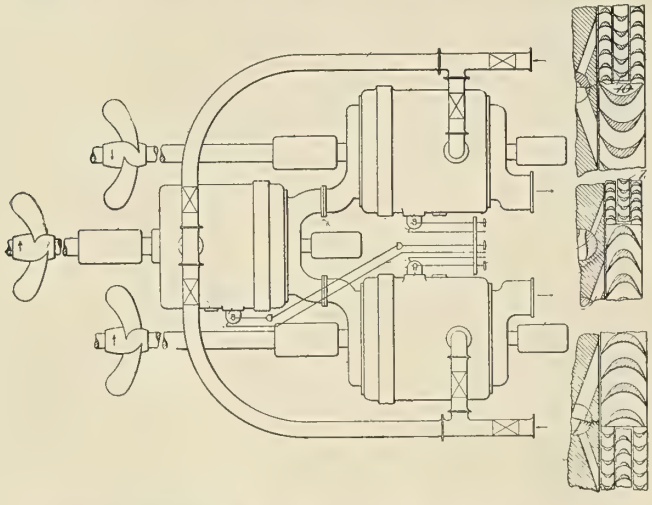
788,005. CONTROLLER MECHANISM FOR TURBINES. JAMES WILKINSON, BIRMINGHAM, ALA., ASSIGNOR TO WILKINSON TURBINE COMPANY, BIRMINGHAM, ALA.

Abstract.—One object of this invention is to simplify the means for controlling a reversing or two-speed turbine wherein independent nozzles or groups of nozzles operate with different driving effects upon one or more compound bucket-wheels. More specifically, it is an object of the invention to dispense with the plurality of supply-valves which in common practice are utilized to vary the flow of motor fluid through the several supply nozzle-passages and to substitute therefor a multiported controller-valve through which the motor-fluid supply for the whole turbine flows directly into the nozzle-supply passages, the valve being adjustable to determine the groups of nozzles to which pressure is to be supplied and the controller device acting to determine the volume of motor fluid admitted to the active working passages. Twenty-six claims.

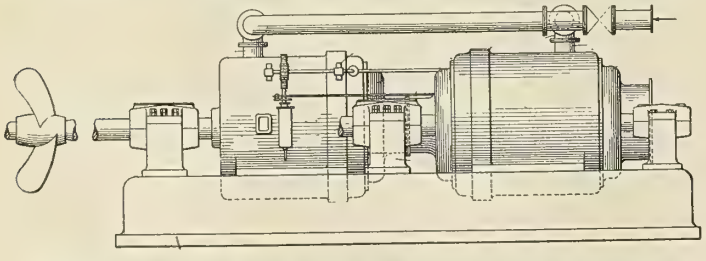


788,006. COMPOUND MARINE TURBINE, JAMES WILKINSON, BIRMINGHAM, ALA., ASSIGNOR TO WILKINSON TURBINE COMPANY, BIRMINGHAM, ALA.

Abstract.—The invention relates to improvements in a compound marine turbine the several turbine units of which are so constructed and coupled as to secure in a comparatively simple manner and without loss in the efficient action of the motor fluid the requisite variations in speed and power as well as independent control of the several propeller-shafts necessary for the successful propulsion and steering of vessels, and at the same time to adapt one or more of the turbine units to reversal with high torque.



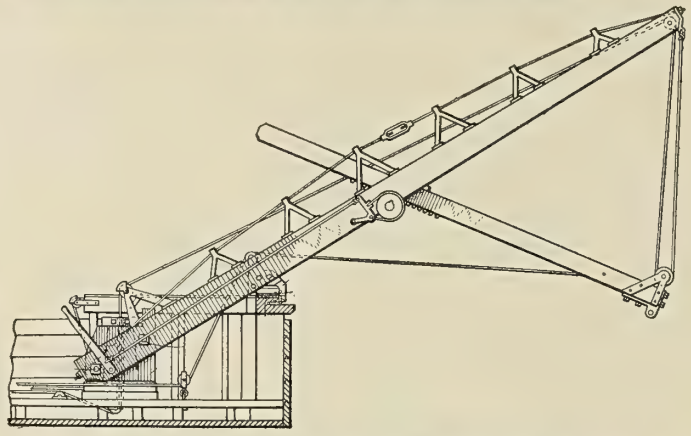
Patents have been issued for turbines provided with independent groups of working passages designed to drive the shaft at two speeds—one representing full and the other cruising speed—and adapted to reverse the vessel at half speed or drive it forward at cruising speed in addition to their normal operation in driving forward at full speed. It is the purpose of the present invention to combine these novel types of turbine to provide a multiple or compound marine turbine of high efficiency and wide range of usefulness which is compact in form and capable of being readily controlled. To this end there is provided a group of three two-speed turbines, each of which drives a separate propeller-shaft and is provided with an independent controller mechanism, so that they are capable of inde-



pendent action. Motor fluid to drive the vessel forward is admitted to the initial or high-pressure two-speed non-reversible turbine, to which the secondary two-speed reversible turbines are coupled by suitable conduits in what may be termed "multiple series"—*i. e.*, a separate conduit leads from the exhaust-head of the high-pressure turbine to the supply-head of each secondary turbine, from which the pressure has access to the full-speed forward-driving working passages of each of these latter turbines under the control of their respective controller mechanisms. When reversing the vessel, these secondary units become high-pressure turbines, the motor-fluid pressure being admitted directly to their high-torque reversing working passages, while their controller mechanisms close the forward-driving working passages. Thus being independent, one of these latter turbines may operate in series with the initial turbine while the other is reversing, or both may operate in multiple, driving the vessel forward, or both may reverse when the high-pressure turbine will be out of service, its only communication with the exhaust or condenser being through the full-speed working passages of the secondary turbines which are then maintained closed. For cruising motor fluid is admitted to the half-speed working passages of the initial turbine to drive its propeller-shaft slowly, and the fluid exhausting into one or both of the secondary turbines will be lower in pressure than when operating at full speed, so that the speed and power of these latter turbines will be reduced. This will effect a relatively slow speed of propulsion of the vessel without sacrificing any economy in operation. Twenty-four claims.

789,322. CRANE AND BLOCK FOR DREDGE-BOATS. GEO. W. GERHART AND JOS. B. GERHART, OF LAWRENCE CO., ILL.

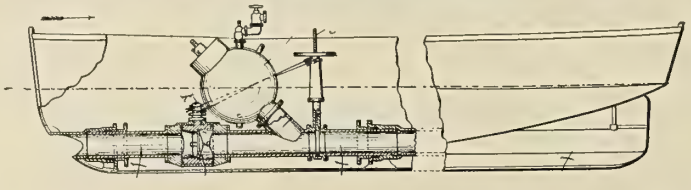
Claim.—2. In a crane for dredge-boats, the combination with the crane and pivoting means, of a segmental track for supporting said crane, said track being constructed so as to allow the crane to be lowered.



5. In a crane for dredge-boats, the combination with the crane, of a crane pivot-block to which said crane is secured and a crane-block pivot-pin constructed to receive said crane pivot-block and provided with a central opening through which the bucket-operating cable passes. Five claims.

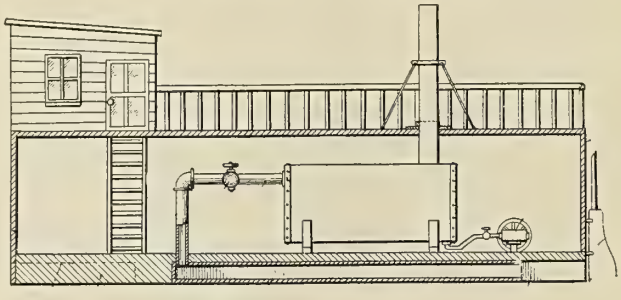
789,334. APPARATUS FOR PROPELLING SHIPS OR BOATS. FINGAL CECIL ORR, STILLORGAN, IRELAND.

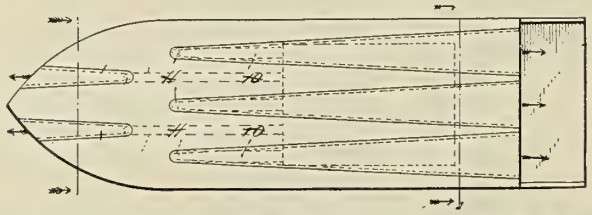
Abstract.—In this invention the ship or boat is propelled by the explosion at short intervals of time of gas or explosive vapor or petrol or other explosive material acting directly on the water through a pipe or pipes provided with non-return valves and opening out of the vessel ahead and astern below the water-line and arranged in such a manner that the expansion of the gases resulting from the explosion forces the water from the pipe or pipes at the stern or at the bows, according to which of the



non-return valves is open, which has the effect of propelling the vessel in the opposite direction to that in which the water is being expelled. The invention consists principally of improvements in the construction of the combustion-chamber and parts immediately connected therewith whereby the explosive charge in the combustion-chamber is maintained under any desired degree of compression until firing and then acts upon the water in the water-tube when the maximum explosive pressure has been reached, so that by this means the full benefit of the pressure due to the compression and explosion of the charge is obtained and after each explosion the pressure of the products of the previous combustion in the combustion-chamber falls to a low pressure, so as to insure economy in working. Six claims.

789,641. BOAT PROPELLING MECHANISM. JOHN A. WEEKS, TULSA, I. T., ASSIGNOR OF ONE-HALF TO LUTE L. LEWIS AND ROBERT H. PATRICK, TULSA, I. T.





Claim.—4. In a boat propelling mechanism a plurality of disconnected tapered ducts having their larger ends disposed, respectively, at the bow and stern of the boat, and means for supplying a fluid under pressure to the ducts. Four claims.